Baseline Habitat Evaluation and Evaluation of the Impacts of City Activities

Prepared for:

City of Corvallis, Oregon

February 12, 2002

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and
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This document is not intended to be a complete inventory of Corvallis stream and riparian areas. Rather it provides a sufficient chinook salmon habitat baseline and analysis of the effects of City activities on that baseline, to ensure compliance with the ESA Section 4(d) Rules as written by the National Marine Fisheries Service.

EXECUTIVE SUMMARY

The final Endangered Species Act (ESA) 4(d) Rules released in the Federal Register July 10, 2000, pose challenges to cities such as Corvallis. The following is a brief discussion of the challenges and risks the final rules may present to the City of Corvallis (City) and the proposed methodology to identify, evaluate, and quantify the impacts on chinook salmon habitat from City government and private citizen activities and behaviors.

Under the 4(d) Rules, Corvallis is required to develop a program that will protect the listed species of chinook in the upper Willamette Basin. The rules have far-reaching implications for City activities, including design, operation, and maintenance of public works; land use; parks and recreation; private development; and public development activities.

Section 9 of the ESA prohibits taking species listed as threatened and endangered. The term “take” is broadly defined to include any activity that harms or kills listed species. The National Marine Fisheries Service (NMFS) recently defined the term “harm” to include significant habitat modification or degradation that actually kills or injures listed species by significantly impairing essential behavioral patterns. These essential behavioral patterns may include spawning, rearing, and migration.

Section 4(d) of the ESA provides that NMFS may adopt regulations it deems necessary for the conservation of threatened species. The NMFS 4(d) Rules identify activities the agency believes may constitute a take of listed species. The rules also identify activities that “conserve” listed species; that is, activities conducted pursuant to NMFS-approved land use regulations. The rules identify 13 activities or programs that NMFS believes will limit impacts on salmonid species, so added protection through application of ESA Section 9 will be unnecessary.

The pathways analysis is the scientific approach that the City of Corvallis has taken to evaluate activities within the urban growth boundary (UGB; see Figure 1, Location and Study Area Map). It is the result of careful review of the Section 4(d) plan regulations and detailed discussions with NMFS staff scientists and was created to provide a methodology that will achieve the Section 4(d) Rule objectives. The pathways analysis seeks to assess the impact on chinook salmon habitat by identifying the link between the activity (e.g., City-provided infrastructure services, activities, and the regulations and codes that regulate these activities; and private citizen behavior), and the chinook salmon habitat. This so-called pathway or conveyance is the way an activity can affect the habitat.

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Figure 1: Location and Study Area Map

Click on evaluation Figure 1 on documents page to view project location map.

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Ecological Risk and Take Issues

The analysis begins with an assessment of the ecological risks associated with take. Take, with respect to this project, is defined as those actions having a direct or indirect effect on the individual fish or habitat. They include killing or otherwise harming, harassing, or preventing the fish from carrying out its normal biological activities**.** The diverse and variable life histories of salmonid species create a number of problems for any agency wishing to develop a protection program. To determine the level of protection afforded a species, it is necessary first to assess the nature of risk to each life history stage.

Changes in stream structure that produce temperature changes (see below) also influence dissolved oxygen levels. A combination of decreased flows, increased shallow pools, and higher temperatures produces lowered dissolved oxygen concentrations. This increases the stress on fish and could result in decreased life expectancy. Increases in nutrients produced by fertilizers and other organic materials transported into the stream by runoff also may cause increased algal or macrophyte production. Vegetation die-offs, whether natural or caused by herbicides transported into the system, and the resultant breakdown of this organic material, also cause a decrease in dissolved oxygen in the stream. The introduction of herbicides, pesticides, and other potentially toxic materials into the aquatic ecosystem could result in diminished production or mortality of any or all levels of the food chain.

Take of critical habitat occurs regardless of the presence of listed species. The National Marine Fisheries Service identified the key habitat concern to be “properly functioning condition” (PFC). Properly functioning condition refers to stream processes that closely approximate historical conditions. In its final ESA 4(d) Rules, NMFS states that it does not expect cities to attain PFC immediately, but that they should show progress toward attainment. This ruling allows cities to classify aquatic habitat into three categories: areas to be protected (e.g., spawning and rearing habitats), areas to be maintained (i.e., protected from further degradation), and areas that may require rehabilitation (e.g., areas that contain barriers to fish passage and areas channelized or otherwise modified).

Habitat types of interest include spawning habitat, rearing habitat, and movement corridors. Spawning habitats generally consist of riffle or pool tail-out areas with a high percentage of gravel substrate. Rearing habitat contains moderately sized pools with overhead cover. Barriers include impassable culverts, pop-up or other dams, and dewatered areas. Other habitat elements directly influenced by City activities include temperature, turbidity, and food supply.

Spawning areas are threatened by sedimentation, a “flashy” hydrograph (water flow over time), and temperature. Sedimentation fills in the small spaces in spawning beds, thereby exposing the eggs to the risk of insufficient oxygen for survival. A “flashy” hydrograph, one with higher highs and lower lows, influences spawning by flushing spawning gravel with higher flows than normal and by holding fish lower in the system during low-water periods. Water temperatures higher than those preferred result in higher stress levels and resultant transfers of energy to metabolic maintenance and away from activities such as growth and reproduction. They also can cause higher egg and larval mortalities. A number of activities can raise water temperature, including

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high temperature inputs from outside the system, conversion of riffle areas to pools, and removal of riparian cover. Salmonids prefer relatively low water temperatures and are therefore among the first fish to be affected by even small temperature changes.

Loss of cover also contributes to changes in stream structure and threats to rearing habitat. Removal of riparian cover leaves streambanks susceptible to both instream erosion and erosion from water entering the stream. It reduces shade, causing water temperatures to increase, and removes the sources of large woody debris.

Many culverts that were constructed in the years prior to the listing of salmonid species either stop or impede fish movement, causing a change in their normal behavior patterns. This constitutes a "take". So also is stream channelization that acts as a barrier to fish movement. Actions that influence the food chains or webs utilized by listed species, thereby resulting in diminished growth and/or reproductive opportunities for individual fish, has been interpreted as a take under ESA rules.

Baseline Analysis

The next element is an analysis of the baseline features of the streams in the study area. Each stream is summarized in the body of the report. The streams in the Corvallis area, with the exception of the Willamette River, contain no listed species. Nor is there any historical record of spawning or rearing in any of them. It is likely, given their size, hydrology, and geomorphology, that they never have been "chinook" streams. Impacts to spawning and rearing areas, therefore, are not critical elements in determining the potential for take resulting from actions by the City.

Despite this, the streams play a role in the baseline water quality of the Willamette River. Water quality is likely the area most important to fish migrating past Corvallis. Riparian functions also are critical—as shade sources to decrease temperatures, as filters for removing contaminants, and as stabilizers to help prevent instream and bank erosion. In the lower reaches of the streams, riparian areas have been severely diminished by development (Figure 2; Reach Locations Draft). Channelization is another result of increased development. The need for streams to become stormwater conduits serves to further contribute to incision and diminishes and eventually removes altogether the floodplain connectivity of the system. The streams also have served as high-water refuge habitat. Barriers at their mouths impede this use. Therefore, impacts from contaminants, impervious surfaces, riparian buffers, and instream habitat conditions (erosion and excessive sedimentation) all play critical roles in the determination of water quality. The result of all this activity, along with the basic human activities associated with living, is diminished water quality in these streams. Eventually this makes its way to the Willamette River, where it can become a take.

The Willamette River differs from the other streams, however, as both immigrating adults and emigrating juveniles use the reach at Corvallis as a passageway. Adults move upstream from April through June and juveniles move downstream from February through May. Some additional movement occurs in October and November. It may be that some use the off-channel habitat on the east side of the river as a resting area. The migratory use of the river makes activities that affect the Willamette more critical in terms of take of listed species.

Figure 2: Reach Locations Draft

Click on evaluation Figure 2 on documents page to view stream reach locations.

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It is clear from the available data that the baselines of all the streams, including the Willamette River, are degraded considerably from their probable condition prior to human settlement. They are urban streams and show all of the attendant characteristics. The channels are incised and straightened and the riparian buffers are reduced in size, continuity, and composition. Off-channel habitat in the Willamette River has become considerably reduced or disappeared altogether. While this plays a lesser role in the establishment of the baseline condition, the distinction becomes more important when a trajectory for recovery is considered.

Analysis of City Activities

After the summary of the baseline habitat condition, the report summarizes the effects of City activities—both regulatory and infrastructure—and the pathways through which these activities affect the baseline. City infrastructure activities, including stormwater and wastewater systems, potable water systems, street cleaning, and transportation elements, significantly impact the habitat baseline. All pathways are implicated in these effects.

Stormwater

The stormwater collection and conveyance system is perhaps the most obvious in terms of its influence, and likely the most far-reaching, as it is the conveyance for a number of the other activities as well. Chief among these is the impact upon the streams by changes to the hydrograph. The number of outfalls in the system and the relatively little onsite detention means that the greatest amount of stormwater acts as Hortonian overland flow into the streams, rather than percolating and entering the streams gradually through the groundwater system. This changes the instream fish habitat and alters flows and erosion/deposition patterns. Since the streams around Corvallis are part of a closed system, the most negative effect is the increased sedimentation rate brought about by increased velocity or decreased infiltration. The pathways also are affected by temperature changes: through the warming of water in either detention facilities or shallow pools that form when flows are low during the non-rainy season.

The elements of the stormwater system that negatively affect the pathways are culverts which pose a barrier to fish movement (also a transportation impact) and fertilizers, herbicides, and pesticides for vegetation control and maintenance along ditches and streams. Other contaminants and sediments are introduced into the system through the flushing process. Ditch-mowing, too, contributes to runoff and the introduction of contaminants.

Wastewater

Wastewater impact pathways include the introduction of contaminants and alteration of temperature. There are a number of potential scenarios involving spills and discharges that would introduce raw pollutants or treatment chemicals directly into the system (e.g., spills, overflows, leaking pipes, and pumping system failures). This type of discharge could have both directly toxic and sublethal effects on the fish themselves, but habitat impacts are likely to be negligible. New construction (such as the pipelines the City is planning along stream systems) would have impacts related to the construction, such as increased sedimentation and erosion, and impacts

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related to the removal of riparian vegetation (the buffer pathway), such as increased temperatures as a result of the loss of shading.

Drinking Water

The potable water system is affected when raw water is withdrawn (instream habitat pathway) and then returned to the system through the wastewater and stormwater systems, causing changes in flows. The dam across Rock Creek (barrier and flow alterations) also affects drinking water, though it probably is not a barrier to listed species. Chemical contaminants are introduced into the system via the use of fertilizers, pesticides, and herbicides for maintenance along watercourses; the backwashing of water filters; and the flushing of pipes. Scheduling becomes critical because maintenance performed during low water conditions does not benefit from dilution effects, making impacts that much greater.

Transportation

The two major areas of transportation-related impact are new construction and maintenance. New construction includes actual construction activities, the road itself, increased traffic, and increased maintenance. Construction within the corridor will have immediate impacts resulting from increased erosion related to the construction activities, increased impervious surface and resultant stormwater runoff-related changes to the hydrograph, and inputs of contaminants from the road surface. The continuity, composition, and width of the riparian vegetation buffer also will be affected.

Construction outside the stream corridor can still have negative impacts through the impervious surface and contaminant pathways. In addition to changes in the stream hydrograph and the introduction of contaminants mentioned above, an increase in the amount of road surface enables an increase in traffic, leading to more contaminants on the road surface.

Similar impacts to the habitat baseline result from the existing transportation system. Contaminants enter the stormwater system from roadways. Maintenance associated with de-icing roads introduces contaminants either directly into the system or into the stormwater system, with the same eventual destination. Similarly, the use of any pesticides, herbicides, and fertilizers, either along the watercourses or in areas where the effluent is conveyed by the stormwater system, have a negative effect on fish in the system and on critical habitat through effects on the food supply. Roadside mowing decreases the ability of the vegetation to slow overland flow and allow the stormwater to percolate. Bridge washing uses detergents that may have some toxic or sublethal effect on fish or their food organisms.

Road repair uses petroleum-based compounds that could be transported into the stormwater system and then to the stream itself, creating a toxic situation. Bridge repairs and painting may introduce substances of unknown toxicity into the systems directly. Culvert cleaning and repair are likely to introduce sediments into the stormwater or stream systems, causing an increase in total suspended solids. These impacts are likely to be sublethal in nature, influencing feeding and navigation capabilities.

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Parks

An analysis of park planning, construction, and maintenance indicates two major pathways for impacts on fish habitat: impervious surfaces and contaminants. Parks have an impact on habitat through their design and maintenance. Design elements include trails, parking lots, park structures, and playing fields. All of these modify conditions to some degree, as they can become impervious surfaces. Since parks have no stormwater facilities, most impervious surface contributes to sheet flow into the streams. While it is likely that some sod areas have some infiltration of stormwater, asphalt and heavily compacted dirt, gravel, and grassy surfaces (particularly mown grass) effectively increase sheet flow into the streams so that use of the park itself becomes an issue.

Pesticides, herbicides, and fertilizers, while useful for park maintenance, become contaminants in the stream system. Such nutrients flow into the system through runoff and enhance the potential for eutrophication. Pesticides and herbicides are generally considered to be toxic or to have sublethal effects. These chemicals, when used to maintain park areas near streams, will have a direct effect, even though methods of dispersal are localized. Indirect effects occur as the result of sheet-flow runoff from parts of the park system outside the riparian corridor.

The effects of new parks (park planning) on fish habitat use the same two pathways. New construction also may commit a direct take on critical habitat through placement in the riparian zones or by usurping other hydrologic features (e.g., wetlands).

On the other hand, positive (or neutral) impacts to the baseline also may be incorporated in design. Such elements as stormwater treatment swales and water quality strips along riparian zones would serve to maintain PFC, if not actually enhance it. It also may be possible to incorporate restoration actions into new park design, making the parks positive contributors to obtaining PFC.

Land use

The greatest impacts on the habitat baseline occur, obviously, in the land use arena. All pathways are implicated, both directly and indirectly. Any development in the area increases the amount of impervious surface (i.e., buildings, parking lots, driveways, streets and roads, etc.). The intensity of the impact depends upon the footprint of the development and the level of treatment, if any, of the associated stormwater runoff.

Development also affects the riparian buffer. Crossings and structural encroachments break continuity and species composition is changed, sometimes quite radically. Removal of the trees (e.g., replacing an oak gallery forest with maintained lawns) decreases a great many of the functions of a riparian system, especially those associated with water quality—temperature and filtering. Even a lawn, if compacted sufficiently, can act as an impervious surface, and the grass may be too short to be effective as a filter strip or as shade.

Instream habitat also is affected by development. The streams are separated from their floodplains, as it is not desired that they cause property damage by flooding, and they become

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stormwater conduits that move water rapidly through the area to the Willamette River. Streams also are constrained by infrastructure development—streets and culverts—which act as barriers, another pathway to habitat impacts.

Daily activities associated with human occupation contribute to the contaminant pathway. Fertilizers, pesticides, and herbicides are commonly used (See Dixon Creek for a list of chemicals found in the stream and their uses). Liquid and solid petroleum products, heavy metals, and bacteria also enter the stream systems and affect the baseline. These are considered to be a standard constituent of any urban stream.

It is important to discern differences in intensity of land use for residential, industrial, and commercial areas. For instance, residential low-density housing may have a greater impact on fish habitat because of yard-maintenance. Higher residential density may have more impervious surface and, therefore, more run-off. Industrial land use could be heavy or light and, depending on the activity, could have different impacts. The same is true for commercial land use. The degree of impact is much like residential: it depends in part on the footprint of the development and any mitigation. No codes mandate stormwater treatment and percolation. The structure of the codes serves only to decrease the impact to the environmental baseline by controlling the impervious footprint on a lot; it does not maintain or improve that baseline.

Zoning, by designating land use, determines the extent of impact on the baseline. While it does not necessarily mean that all land in a particular zone is of the type zoned, it does suggest what may occur in the future. Activities in the riparian corridor will have a continued detrimental effect on habitat by way of the riparian buffer pathway because they will affect buffer size, continuity, and species composition, and they will increase impervious surface and contaminant runoff. Activities outside the riparian corridor may not necessarily have this impact, but the potential is there if any of the pathways are operating. As can be seen in the analysis, these pathways are found in most of the development-based activities.

Land Use Development Code

The Comprehensive Plan for the City of Corvallis serves as the projection of development activities. It is the City's most critical land use document, containing various measures designed to (1) permit development in some areas, (2) preserve other areas (e.g, open space, agricultural land, forestry resources, and buffers), and (3) restrict development on sensitive lands, for example, hillsides and floodplains. The plan protects resources such as waterways, riparian zones, forests, and wetlands identified as significant. It also restricts stormwater impacts to such elements as water quality, establishing that they may become no worse than pre-development conditions. The Plan also addresses contaminants and other pathways.

The development code determines what is allowed in development, zoning, etc. It is the Comprehensive Plan made operational. Little of the code addresses habitat impact pathways, although elements mentioned above do specifically preserve riparian corridors and open spaces. Other positive elements are those that limit certain of the pathways, such as impervious surface. However, these do not stop the effects of the activity, but only limit the increase (as above). This still causes an increase in the effects on the habitat and further degrades the baseline. The recent

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nature of the City of Corvallis' Comprehensive Plan is reflected in the fact that the development code has not yet been formulated and implemented.

Conclusion

It is clear from this analysis that the majority of City activities, through any and all of the pathways, have a negative effect on the habitat conditions in the streams of the project area. The greatest impact comes from impervious surface, followed by riparian buffer changes and channelization. Impervious surface results not from just the construction of buildings, streets and roads, and parking areas, but also from such seemingly benign activities as trails and parks. The increased runoff is particularly important in the upper reaches of the Corvallis streams (especially Dixon, Oak, and Squaw). While it also is also important on Sequoia, this stream is not crucial as critical habitat for listed species because of the filtering capacity and passage barrier aspects of the Jackson-Frazier wetland complex. While the lower reaches of the other streams are likely completely incised or nearly so, the upper reaches still retain a great deal of function and hydrologic connectivity. This is likely to change as these areas are designated for increased development and the additional impervious surface that will result.

The City has criteria within its comprehensive and other plans that address the Municipal, Residential, Commercial, and Industrial (MRCI) limits. As such, these elements provide the framework for Phase 2 of this plan: the determination of solutions to the impacts identified in this report.

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PATHWAYS EVALUATION REPORT

OVERVIEW

The Endangered Species Act of 1973 (ESA) final 4(d) Rules released in the Federal Register July 10, 2000, pose challenges to cities such as Corvallis (City). The following is a brief discussion of the challenges and risks the final Rules may present to the City, and the proposed methodology to identify, evaluate, and quantify the effects on chinook salmon (*Oncorhynchus tshawytscha*) habitat from City government and private citizen activities and behaviors. This understanding is based on Shapiro and Associates, Inc.'s (SHAPIRO's) extensive experience working with the National Marine Fisheries Service (NMFS), our knowledge of the 4(d) Rule, and our experience with local jurisdictions in both Oregon and Washington (Puget Sound Tri-County region).

Under the 4(d) Rules, the City will be required to develop a program that will protect the listed species of chinook in the upper Willamette River basin. The Rules could have far-reaching implications for City activities, including design, operation, and maintenance of public works; land use; parks and recreation; private development; and public development. Section 9 of the ESA prohibits taking listed species. The term "take" is broadly defined to include any activity that harms or kills listed species. The term "harm" recently was defined by NMFS to include significant habitat modification or degradation that actually kills or injures listed species by significantly impairing essential behavioral patterns. These essential behavioral patterns may include spawning, rearing, and migration.

Section 4(d) of the ESA provides that NMFS may adopt regulations it deems necessary for the conservation of threatened species. The NMFS 4(d) Rules identify activities the agency believes may constitute a take of listed species. The Rules also identify activities that conserve listed species: that is, activities conducted pursuant to NMFS-approved land use regulations. The Rules identify 13 activities or programs that NMFS believes will limit impacts on salmonid species so that added protection through application of ESA Section 9 will be unnecessary.

According to NMFS, it intends to use the 4(d) Rule process as a way to encourage governments to review their regulations and make changes to ensure activities conducted pursuant to such regulations do not cause a take. Furthermore, NMFS is actively encouraging and is "interested in working with local jurisdictions to develop programs that protect endangered and threatened species and their habitats and to recognize such programs through 4(d) Rules exceptions or other mechanisms" (NMFS 2002).

After take prohibitions become final, all parties, including states, local governments, private citizens, and corporations, must avoid taking threatened species or risk civil and criminal sanctions. Recent federal court cases suggest that states and local governments may be liable for actions they authorize or permit if such actions result in a take. While the federal government may bring civil or criminal enforcement for ESA violations, the ESA also permits any person to initiate a citizen suit to enjoin violations of the Act. Such provisions likely will lead to greater scrutiny of proposed development actions by environmental and citizen groups.

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The issuing of the final 4(d) Rules by NMFS initiated a variety of environmental planning processes within the Puget Sound region and areas in Oregon where fish are listed. The NMFS 4(d) Rules set forth an administrative process whereby governmental entities may except their land use and water quality regulations from ESA restrictions. The agency will evaluate municipal, residential, commercial, and industrial practices using the following criteria:

1. Development will avoid inappropriate areas (e.g., slopes, wetlands, and riparian areas).
2. Avoid stormwater discharge impacts to water quality, quantity, and the watershed hydrograph.
3. Provide adequately protective riparian area management to maintain properly functioning conditions and mitigate unavoidable damage.
4. Avoid stream crossings by roads, utilities, etc, when possible and minimize impacts where crossings are unavoidable through choice of mode, sizing, and placement.
5. Protect historical stream geomorphology and avoid hardening of banks and shorelines.
6. Protect wetlands and wetland functions.
7. Preserve hydrologic capacity of all streams, permanent and intermittent, to pass peak flows.
8. Provide for and encourage use of native vegetation for landscaping to reduce water, pesticide, and herbicide use.
9. Ensure water supply demands can be met without having a negative impact on flows, directly or through influences on groundwater. Any new diversions should be placed and screened in such a way as to prevent injury to and or death of salmonids.
10. Provide necessary enforcement, funding, reporting, and implementation mechanisms and formal plan evaluations at no greater than five-year intervals.
11. Comply with all other state and federal environmental and natural resource laws.
12. Provide NMFS with annual reports regarding implementation and effectiveness.

Critical to the NMFS rulings on take is the concept of properly functioning conditions (PFC). According to “An Ecosystem Approach to Salmonid Conservation” (Spence et al. 1996), NMFS will require the maintenance of such habitat conditions as those physical and biological parameters essential for the conservation and continued well-being of the species. These include water quality (temperature, dissolved oxygen) and quantity and habitat features such as substrate, habitat complexity, cover, etc. The agency further recognizes the dynamic nature of these features, and so has not set any specific static limits or values to attain. Rather, NMFS has focused on processes and the maintenance of those functions at a number of scales.

Compliance with the NMFS rules governing incidental take involves developing an integrated plan that comprises all the operations undertaken by the City. The agency has stated that it will be more inclined to look at such integrated efforts first, rather than approving each individual program as it is presented. In order to accomplish this comprehensive approach to compliance, however, it is necessary to first identify the City's activities and programs and private citizen behaviors that may cause harm to listed fish habitat. This project provides that initial assessment. It will assist the City in determining where it should begin to invest its resources to comply with the ESA 4(d) Rules.

The following report explains the method and evaluation procedure (a pathways analysis) that has been applied, and documents the results. The impacts from activities are summarized in the text and detailed matrices are provided in the Appendix.

INTRODUCTION

The pathways analysis is the first phase in a two-part process to prepare a plan that will prevent chinook salmon habitat degradation. The first phase establishes the baseline conditions within the project area for chinook salmon habitat and assesses the effects City activities have on those conditions. In Phase Two, the City will use the results of the Phase One study to craft programs or modify activities so as to prevent further degradation by those actions that have been shown to degrade chinook salmon habitat. Once developed, the plan will be submitted to NMFS for sanction.

The emphasis under the ESA Section 4(d) Rules (promulgated July 10, 2000) and its regulating agency, NMFS, is to use scientifically defensible methods to identify and evaluate the effects on listed chinook salmon habitat within the City's urban growth boundary (UGB). Based on this scientific approach, the City can make rational decisions on what activities, if any, it may desire to modify, mitigate, or enhance to prevent further degradation and comply with the Section 4(d) Rules. Further, this analysis will allow the City to put itself on a trajectory toward establishing PFC for chinook salmon habitat.

The pathways analysis is the scientific approach the City has taken to evaluate activities within the UGB. It is the result of careful review of the Section 4(d) Plan regulations and detailed discussions with NMFS staff scientists to craft a methodology that will achieve the Section 4(d) Rule objectives.

The pathways analysis seeks to assess the impact on chinook salmon habitat by identifying the link between the activity (e.g., City-provided infrastructure services, activities, and the regulations and codes that regulate these activities; and private citizen behavior) and the chinook salmon habitat. This so-called pathway, or conveyance, is the way by which an activity can affect the habitat.

The analysis begins with an assessment of the ecological risks associated with take. This provides the background for the pathways discussion that follows. The next element is analysis of the baseline features of the streams in the study area. Each stream is summarized in the body of the report; the data reports for each system are in the Appendices.

Following this, the activities (both regulatory and infrastructure) of the City that have an impact on the habitat baseline are summarized. Again, the detailed matrices supporting these conclusions are in the Appendices. The report summarizes the baseline habitat condition, the baseline of impacts from City activities, and the pathways through which these activities impact the baseline habitat condition.

ECOLOGICAL RISKS

INTRODUCTION

The diverse and variable life histories of salmonid fish species create a number of problems for any agency wishing to develop a protection program. To determine the level of protection afforded a species, we first assess the nature of risk to each life history stage. In this section of the report, SHAPIRO biologists identify the life history stages of listed salmon species potentially at risk and those factors likely to cause them harm.

Ecological risks to salmon species listed under the ESA include the elements listed below.

Take

Take is defined as those actions having a direct or indirect effect on the individual fish or habitat. It includes such actions as killing or otherwise harming, harassing, or preventing the fish from carrying out its normal biological activities.

Dissolved Oxygen

Changes in stream structure that produce temperature changes (see below) also influence dissolved oxygen levels. A combination of decreased flows, increased shallow pools, and higher temperatures produces lowered dissolved oxygen concentrations. This increases the stress on fish and could result in decreased life expectancy. Increases in nutrients produced by fertilizers and other organic materials transported into the stream by runoff also may cause increased algal or macrophyte production. Vegetation die-offs, whether natural or caused by herbicides transported into the system, and the resultant breakdown of this organic material, also cause a decrease in dissolved oxygen in the stream.

Temperature

Fish are known to have tolerances and preferences for a number of environmental variables. Temperature may be one of the most important, as its impacts can be both lethal and sublethal. Increased temperature can cause problems at the molecular level by interfering with the functioning of various enzymes, causing physiological problems and even death for the fish. It also can influence the metabolic activity of the fish, changing feeding patterns and assimilation of nutrients, forcing the fish to alter the allocation of energy resources. This re-allocation could have a negative impact on lifetime reproductive output. This sublethal effect may be important in the long-term survival of the population.

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Direct toxicity

The introduction of herbicides, pesticides, and other potentially toxic materials into the aquatic ecosystem could result in diminished production or mortality at any or all levels of the food chain.

Take of Critical Habitat

Take of critical habitat occurs regardless of the presence of listed species. The key habitat concern, according to NMFS, is PFC. Properly functioning condition refers to having stream processes that closely approximate historical conditions. In its final ESA 4(d) Rules, NMFS states that it does not expect cities to attain PFC immediately, but that they should show progress toward attainment. This ruling allows cities to classify aquatic habitat into three categories: areas to be protected (e.g., spawning and rearing habitats), areas to be maintained (i.e., not further degraded by activities), and areas that may require rehabilitation (e.g., barriers to fish passage, reaches that are channelized or otherwise modified).

Habitat types of interest include spawning habitat, rearing habitat, and movement corridors. Spawning habitats generally consist of riffle or pool tail-out areas with a high percentage of gravel substrate. Rearing habitats are moderately sized pools with overhead cover. Movement corridors are simply areas of sufficient water depth to allow unimpeded passage from one area of habitat to another. Barriers include impassable culverts, pop-up or other dams, and de-watered areas. Other elements of habitat directly influenced by City activities include temperature, turbidity, and food supply.

Spawning Habitat

Spawning areas are threatened by sedimentation, a “flashy” hydrograph (water flow over time), and temperature. Sediment can originate from outside the system or from instream erosion. It influences spawning in two ways: by covering and smothering the eggs and by embedding the gravel, thereby making it difficult or impossible for fish to dig redds (spawning sites). A “flashy” hydrograph, one with higher highs and lower lows, influences spawning by flushing spawning gravel with higher flows than normal, and by holding fish lower in the system or in a mainstem during low water periods.

Salmonids prefer lower temperatures. A number of activities can cause temperature increases, including high temperature inputs from outside the system, conversion of riffle areas to pools, and removal of riparian cover. Higher temperatures result in higher egg and larval mortalities, or at least in higher stress levels and their resultant transfers of energy to metabolic maintenance and away from activities such as growth and reproduction.

Rearing Habitat

The major threats to rearing habitat consist of those changes in stream structure caused by higher and lower flows. The scouring and erosion caused by higher and more intense flows cause the stream to spread out and become more U-shaped (as opposed to V-shaped). This change in shape changes habitat structure as riffles and glides convert to pools. This results in higher temperatures, as the new pools have less depth and slower flows. Older pools also become shallower as the channel becomes wider. This decrease in depth strands rearing fish in the summer as flows naturally drop. Increased fine sediment in the system embeds the gravel and coarser sediment necessary for overwintering, making them more difficult to use. Increased side-cutting leads to the loss of undercut banks that provide instream cover.

Loss of cover also contributes to changes in stream structure and threats to rearing habitat. Removal of riparian cover leaves streambanks susceptible to erosion from water entering the stream and to instream erosion. Shade also disappears, causing water temperatures to increase and removing sources of large woody debris.

Movement Corridors

Many culverts constructed prior to the listing of salmonid species either stop or impede fish movement. This causes a change in their normal behavior patterns and thus constitutes a take. Culvert characteristics considered to be impediments include excessive length, excessive velocity through the culvert, darkness, and an excessive vertical drop at the outlet of the culvert. Other impediments to movement include dams, diversion structures, and natural barriers (such as falls and beaver dams). Channelized sections of the stream also act as barriers to movement, with high velocities and little or no resting areas or cover.

Effects on Feeding

Changes in stream sedimentation patterns could result in changes in the structure of plant and/or macroinvertebrate communities. These changes could further result in diminished growth and/or reproductive opportunities for individual fish, representing a take under the ESA.

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PATHWAYS

The pathways used in this report combine the above discussion of take with the assessment of properly functioning condition. A brief description of each pathway, as it is used in the analysis, appears below.

Channelization/Instream Habitat

As encroachment occurs in floodplains, streams become stormwater conduits. This, and the subsequent removal of large woody debris (LWD) from the channel, increases channelization. Channelization causes increased velocity and increased down-cutting erosions. It severs connections between stream flow and groundwater, causes problems in the hyporheic zone, and increases problems for spawning and rearing fish. Channelization also degrades instream cover, off-channel and other refugial habitat, riparian conditions, hydrologic connectivity, food resources, substrate, and instream habitat quantity, diversity, and quality.

Impervious Surface

Properly functioning condition consists of water movement governed by infiltrated groundwater, overland flows, and source flows (e.g., springs, lakes, etc.). System hydrographs have fewer peaks over a longer period of time (i.e., two bankfull flows per five-year interval). Systems with heavy impacts have bankfull events several times a year.

An increase in impervious surface leads to more overland flow, which replaces infiltrated groundwater as the main source of water in the stream. Overland flows generate a greater amount of water in the stream in a shorter period of time. Runoff from impervious surface causes increased instream erosion as the stream equilibrates to the new flow regime. This leads to loss of instream habitat features (e.g., under-bank cover) through erosion, and transport of LWD. It also increases fine sediment initially, while the stream is equilibrating (0 to 20 years). Once the stream reaches its new equilibrium, fines actually decrease (assuming no channelization—this activity prevents the channel from reaching equilibrium).

The principal effect of increased flows is to widen the channel. This occurs because the stream must accommodate these greater flows. Bankfull width increases and pools fill in. As stream flow spreads out over a wider area, it slows and temperature increases because of the slower passage, loss of riparian shading, and greater surface area to be heated. Continued erosion leads to the loss of overhanging cover in the pool areas. Increased sedimentation and the subsequent slowing of flows and filling of pools by finer sediments causes a loss of spawning and rearing habitat. As the channel reaches equilibrium, the higher flows flush the finer sediments away. This leaves coarser sediments, which may be better for spawning activity, but spawning activity is diminished if the connection between the groundwater flows and surface flows is severed as the result of changes in the hyporheic zone. The higher flows also may wash fish away and the lower lows may strand them in summer when rearing is important.

The chief pathway for this change is increased impervious surface contributing to greater surface runoff and less infiltration. This leads to higher flows and a “flashier” hydrograph. Secondary

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pathways could be the loss of riparian habitat and decreased groundwater flows—the latter as at least the partial result of reduced infiltration of stormwater. Increased impervious surface is the direct result of increased development of all types. The more concentrated the development, the greater the amount of impervious surface. At a level of about 10% total impervious surface, stream habitat begins to suffer. As previously discussed, streams will adjust to the new flow levels. Once the stream's flow reaches equilibrium, riparian issues become more important.

Riparian Areas (Buffers)

Impacts on Riparian Buffers

Riparian areas influence fish habitat through many significance elements, including the temperature element, the contaminant element, and vegetation type. Properly functioning condition consists of buffer widths, continuity, and structure sufficient to provide shading, filtration of overland flow, LWD, and protection against streambank erosion.

Riparian areas regulate temperature, which plays a critical role in the regulation of fish physiological function. The Clean Water Act sets temperature limits for cold-water fish species (e.g., salmonids). The presence of vegetation serves to create cool-water refugia microclimate areas for fish to escape the generally warmer temperatures in other portions of the stream. Contrary to popularly held opinion, heat is not necessarily retained in streams, so under the appropriate shade regimes, streams will cool down. Tall conifers perform this function best, but any woody or even tall herbaceous vegetation along the streambank or on a south slope also will do this, depending on the size of the stream. Riparian areas with shrubs or young trees provide less shade function to a stream. Grasses shade even less and manicured grasses provide no shade function. Elements important to this function include vegetation type and height, stream width, stream orientation, and stream flow.

Densely vegetated riparian areas act as filters for contaminants, which include sediments, nutrients, and streambank erosion. Recent research suggests that grassy buffer strips may filter out contaminants better than woody vegetation, but any vegetation will do this at some level. Important elements for this function are vegetation type, buffer width, riparian continuity, and slope.

Aside from acting as a filter, vegetation also binds the streambank, reducing erosion. This reduces the collapse of the banks, allowing the stream to undercut them and thereby creating fish habitat. This undercut bank habitat also may serve as a cool-water refugium. The securing of banks is an under-appreciated feature of grassy riparian zones. The prevention of instream erosion and the filtration of sediments keep important habitat features, such as spawning gravels and rearing pools, from silting in. This prevents mortality of the eggs from anoxia. It also maintains pool depth, which prevents summer mortality.

Large woody debris creates pools and other instream habitat features, as well as substrate for invertebrates—potential food sources. This is a product of vegetation type: a zone with no large trees will contribute no LWD to the stream channel.

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Three key elements of riparian condition, when subjected to change such as that which accompanies development, have a negative effect on the condition of the stream. Decreased buffer width tends to act like impervious surface, causing an increase in instream erosion and an eventual loss of habitat structure and diversity. The increased Horton (overland) flow of water also contributes more sediment and contaminants. Insufficient buffer size and structure diminish the functions of filtration and infiltration, which regulates the flow of groundwater back into the stream. Riparian continuity, estimated by impingement, also plays a role in nutrient and habitat inputs to the stream. The presence of LWD is diminished by lowered riparian connectivity, as is the structure of the riparian zone. Vegetation type affects LWD recruitment and bank stability: any vegetation on the bank will provide protection against erosion, although quality varies. If the riparian zone consists of lawns or manicured grasses, not only does it provide no it can act as impervious surface.

Barriers

Barriers to fish movement include such structures as culverts and pop-up dams. Culverts create an environment where flows become considerably more powerful, but also may serve as low-flow barriers to movement. Dams without fish passage serve as blockage to movement during all flow regimes. Barriers are critical as they do not allow adult fish access to spawning habitat, they do not allow juveniles access to rearing and refugial habitat, and they do not allow juveniles downstream passage.

Contaminants

Contaminants in the water may have a direct effect, through toxicity to one or more life stages of the fish or other elements of the food web, or indirect effects, such as sublethal impacts on growth and vitality. These effects are difficult to separate from background individual variation within a population, as well as from seasonal changes. They can, however, be highly important in the long-term survivability of the population, as their impact tends to be on lifetime reproductive output—usually through effects on growth, reproduction, sensory or motor functions, or food supply.

As can be seen by the complexity of the various pathways, channelization, impervious surface, and riparian buffers have the most diverse potential for impacts leading to take. In order to determine the impacts of City activities and set the habitat baseline for these impacts, the stream condition in the project area must be assessed and the nature and extent of current and future City regulatory and infrastructure activities must be determined.

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STREAM BASELINE ANALYSIS

The analysis uses as its template the "Matrix of Pathways and Indicators" developed by NMFS. This enables the use of the same techniques NMFS used as a framework for the major habitat categories. Further breakdown into specific elements will follow, along with conditions for establishing degraded, at risk, and properly functioning conditions, and the pathways for arriving at those conditions. The conditions for the analysis—the habitat elements, impacts, and pathways—are those established earlier in this document.

Assessment of Corvallis Streams

Dixon Creek (From CSMP 2000)

Dixon Creek originates in the hills to the northwest of Corvallis. Most of its length lies within the City, where it is an important feature of many residential backyards. It also runs through several school properties and parks before reaching commercial property at 9th Street and Reiman Avenue and shortly thereafter the Willamette River. The Dixon Creek watershed contains 2,712 acres. The largest land use is low-density residential, which covers more than one-third of the watershed. In addition, medium-density residential, Oregon State University (OSU) forestland (McDonald State Forest), and vacant parcels each cover about 400 acres.

If the watershed is developed to full build-out according to the City of Corvallis' Comprehensive Plan (1998), the vacant land may be largely converted into low- and high-density residential use. Other changes may include a decrease in medium-density residential and an increase in commercial land use. Overall, the number of impervious acres is estimated to increase by 13%, from 897 acres to 1,017 acres.

Habitat evaluations were made using both the Streamwalk conducted by Watershed Applications and field analyses conducted by SHAPIRO.

<u>Temperature</u>

The City is evaluating temperature at four permanent monitoring sites in Dixon Creek. Thermistors at the sites record the water temperature hourly.

<u>Sediment/Turbidity</u>

The high levels of fine sediment found throughout the Dixon Creek watershed likely are a function of the local geology and urbanization. In the vicinity of Dixon Creek, the Willamette valley floor is composed nearly entirely of silty-loam soils (USDA 1975). Therefore, high levels of fine and suspended sediments are likely natural features of the stream. Stream incision and bank erosion likely have added to the natural loads of fine and suspended sediments. Nutrient inputs from urban landscaping and fertilizing likely have increased the amount of algae in the stream and contributed to higher turbidity levels.

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Chemical and Nutrient Contamination

The U.S. Geological Survey assessed Dixon Creek during its sampling in the mid-1990s. The chemicals found in it placed it in the non-agricultural category. These included Carbaryl (Sevin), used for both home and landscape applications; Dichlobenil (Casoron) and Tebuthiuron, used to control broadleaf weeds and under asphalt and railway rights-of-way (ROW); Diazinon, whose use is similar to Carbaryl; and Prometon, which is used in urban landscaping, ROW, and industrial applications, and by homeowners. Dixon Creek also exceeded standards for temperature, fecal coliform, and *Escherichia coli* bacteria. It appeared to have no excessive nutrients. It is likely, too, that this stream carried the "usual" urban runoff components of metals and petroleum products.

Physical Barriers

A partial barrier exists at the confluence of Dixon Creek and the Willamette River. The box culvert under Highway 20 has been modified to promote fish passage by creating deeper, slower flows through a portion of the culvert. However, because the culvert is perched and falls onto riprap, access to the culvert's fishway may be restricted to times when the water level in the Willamette is near the culvert outfall.

Flat-bottomed box culverts located at 3rd Street, 4th Street, Buchanan Avenue, Kings Boulevard, 29th Street, and Walnut Boulevard may pose additional passage problems during high and low flows. Dace were observed in the stream up to 29th Street, indicating that all of these box culverts are likely passable during some flow conditions.

Substrate

Exposed clay layers, silt, and riprap are the most common substrates in Dixon Creek. The high levels of silt and lack of gravel likely are a function of the local geology. No rock outcroppings or colluvial debris slides occur in the watershed to serve as a source of coarse stream sediments. Moreover, the silt loam soils that dominate this area of the Willamette valley (USDA 1975) are likely the dominant streambed material in the small wetland channels that historically appeared in the Corvallis area. The prevalence of exposed substrate probably is the result of urbanization along Dixon Creek. Channelization and changes to the creek's hydrograph have led to increased downcutting of the streambed and the exposure of clay layers formerly covered by the more erodible silt soils. The large quantities of riprap in the channel result from the frequent bank stabilization efforts needed to protect the highly erodible streambanks.

Large Woody Debris (LWD)

The small amount of LWD in Dixon Creek does not contribute significantly to stream complexity or aquatic refuge. Most pieces of wood in the creek are small-diameter deciduous logs that decay rapidly and have little potential to create significant instream cover. The highest concentrations of LWD are in the small headwater streams of Dixon Creek where fish presence is unlikely, as is downstream transport of the LWD. Recruitment potential is limited by the reduced size of the riparian zones and channel incision.

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Pool Frequency

Long, trench-like scour pools with long, glide-like tail-outs are the dominant habitat types in reaches of Dixon Creek that could potentially support salmonids. However, pool frequency does not meet the 184 (or 96 pools per mile) standard established by NMFS. The long pool lengths preclude sufficient numbers of pools from occurring in any 1-mile (1.6 kilometer) length of stream.

Pool Quality

Pool quality in Dixon Creek is low. Deep scour or trench pools are abundant in Dixon Creek; however, they lack structures such as LWD and undercut banks that provide cover for fish. Reduction of pool depth because of sediment deposition is not a concern in Dixon Creek. The channelized nature of the stream ensures that all deposited sediments are washed out of the system during high flow events.

Off-Channel Habitat

Channel entrenchment in the lower reaches of Dixon Creek precludes the formation of off-channel habitat. No off-channel habitat exists in stream reaches that may potentially be in the mainstem of Dixon Creek or the lower portions of the tributary streams.

Refugia

Dixon Creek was likely a braided wetland channel surrounded by gallery forests before settlement by Euro-Americans. Land conversion and urbanization have dramatically changed the nature of the stream and its riparian areas. While a small amount of remnant aquatic refugia may exist in the headwater streams, none was observed during the survey. The natural wetland channels have been converted to a single entrenched channel. Gallery forests and riparian wetlands have been replaced with residential developments. Riparian buffers are narrow and have been overrun by invasive species such as Himalayan blackberry (*Rubus discolor*) and bedstraw (*Galium* sp.).

Width-To-Depth Ratio

Width-to-depth ratio is estimated to be approximately 8, which meets the NMFS criteria for PFC. However, because the channel is entrenched and revetments often prevent the stream from widening, this indicator may not be appropriate for use in evaluating stream health. The low width-to-depth ratio is more a function of degradation caused by urbanization than preservation of natural habitat conditions. Habitat features usually associated with low width-to-depth ratios, such as lower stream temperatures and instream cover, are not characteristic of the conditions in Dixon Creek.

Streambank Condition

The condition of streambanks in Dixon Creek is variable. The stream is undercutting root masses of living trees and bank erosion is common in the upper watershed. In areas where root masses are being undercut, future bank erosion is likely as the trees fall and expose unstabilized soils. Large portions of the streambanks have been armored with riprap, gabions, and log bulkheads. As more impervious surface is added to the watershed, bank erosion and undercutting likely will increase.

Floodplain Connectivity

Channel incision has severed much of the natural hydrologic link between the floodplain and the stream channel. Incision depth in the mainstem of Dixon Creek averages approximately 2.5 meters (8.2 feet). High flows that once regularly exceeded the streambanks and inundated the floodplain are now confined to the entrenched channel. Over-bank flooding now occurs only during extreme runoff events. Wetland riparian areas that once bordered the creek have become perched and drained as the water table has deepened.

Peak and Base Flows

Peak and base flows undoubtedly have been altered by the loss of riparian wetlands, channel incision, and land conversion and the addition of large amounts of impervious surface to the watershed. The loss of floodplain wetlands caused by channel incision has decreased the watershed's capacity to store water and likely has resulted in decreased base flows. Channel incision has increased the conveyance in the watershed and has contributed to sharper peaks in the stream hydrograph. The addition of large amounts of impervious surface, coupled with stormwater conveyance systems, creates a pathway by which precipitation is collected and quickly piped to the stream rather than percolating into the groundwater or slowly trickling into the stream. This rapid transformation of precipitation to runoff creates unnaturally high, sharp spikes in the hydrograph of Dixon Creek.

Road Density and Location

Road density in the urban environment of Dixon Creek is very high. A significant portion of the watershed is covered with impervious surface. Roads closely parallel the stream in many places and numerous road crossings fragment the aquatic and riparian habitat.

Disturbance History

More than 60% of the Dixon Creek watershed has been developed for commercial or residential purposes. Very little late successional or old growth forest remains in the area. Because of the permanent nature of urban development, no significant improvements to this indicator are expected.

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Riparian Reserves

Approximately 80% of the riparian area in the watershed is developed. Riparian vegetation in the developed areas is confined to the land at or below the top-of-bank. At least 33 road crossings dissect Dixon Creek. These crossings reduce the connectivity and create a discontinuous series of isolated riparian areas.

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Squaw Creek

Squaw Creek runs from Bald Hill Park west of Corvallis eastward to its conjunction with the Mary’s River at Brooklane Drive. The Squaw Creek watershed contains 2,363 acres. The largest land uses in the watershed are low-density residential (766 acres) and vacant land (609 acres). Some land in the watershed is used for industry and commerce, although this is mostly limited to the Sunset Research Park and along Philomath Boulevard (Highway 20/34). If the watershed is developed according to the City of Corvallis’ Comprehensive Plan (1998), all of the vacant land may be developed, with most of it converted to residential use. In addition, medium- and high-density dwellings will make up an increasingly larger portion of the residential land use. As a result of these changes, the amount of impervious land may increase from 762 to 968 acres, an increase of 27%.

<u>Temperature</u>

Temperature was not assessed because the survey period did not overlap with the summer months when stream temperatures are of greatest concern. The City of Corvallis has begun a year-round temperature assessment.

<u>Sediment/Turbidity</u>

Squaw Creek contains high levels of fine sediment. Silt, sand, and organic matter are the most common substrates. The water in the creek is dark and visibility is no greater than 0.5 meter (1.6 feet). The high level of fine sediment and turbid nature of the water likely are caused by the natural geology of the watershed rather than human disturbance. All alluvial layers exposed by the stream are composed entirely of clays and fine sediment. The slow, flat nature of the watershed allows for accumulation and decomposition of organic material, as well as algae bloom. The high turbidity of the creek likely is caused by tannic acid or other solutes produced by decomposing organic material that have accumulated in the stream.

<u>Chemical Contamination</u>

The urban chemicals that may be present in this basin are the same as those potentially present in Dixon Creek (see page 21). Some agricultural chemicals such as atrazine and related compounds may also be found in Squaw Creek.

<u>Physical Barriers</u>

A retaining wall just upstream from the confluence of Squaw Creek and the Mary’s River creates a 1-meter (3.3-foot) drop that poses a barrier to fish passage. The height of the falls and the lack of a plunge pool below it eliminate the possibility of fish migration from the Mary’s River into the Squaw Creek watershed. Reconstructing the retaining wall to make it passable to fish would have limited benefits because of the poor quality of upstream habitat.

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Substrate

Clay, silt, sand, and organic materials dominate the substrate in Squaw Creek. The natural geology of the watershed, as opposed to the human disturbance, likely is the cause of the high level of fine sediment. Coarse substrates other than riprap were not found in significant quantities in any portion of the watershed and appear to be absent from all alluvial layers exposed by the stream. Moreover, the flat topography of the watershed does not create enough stream energy to produce the downcutting needed to expose sources of coarse sediment or to transport such sediment once it has been exposed. Without a source of gravel and cobble substrates, Squaw Creek appears always to have been devoid of coarse substrates.

Large Woody Debris (LWD)

Large woody debris is scarce in the Squaw Creek drainage. No pieces that match the NMFS definition of 24-inch (0.6-meter) diameter and 5-foot (1.5-meter) length were observed in the stream channel. Small accumulations of woody debris are common in many reaches. Because of the small size of Squaw Creek and the low energy of its flows, these accumulations are able to persist within the active channel, functioning similarly to pieces of LWD. These accumulations create small pockets of scour and could provide cover to any fish that potentially inhabit the creek.

Pool Frequency and Pool Quality

Pool frequency and pool quality are very low. Aquatic habitat is composed largely of slowly moving, slack water glides. Riffles are short and infrequent. Pools with significant scour are even more infrequent. One large-diameter pool is present in Reach 2 (see Figure 2 for reach locations). It is created by a relatively large debris jam.

Off-Channel Habitat

The pond near the top of the south fork and the millpond on the north fork are the only two significant areas of off-channel habitat.

Refugia

Intact, well-buffered riparian areas exist in few areas of the Squaw Creek watershed. Residential and commercial developments, city parks, and agricultural fields all encroach into Squaw Creek riparian areas. This disturbance to riparian habitat has aided the invasion of species such as reed canarygrass (*Phalaris arundinacea*) and Himalayan blackberry. Approximately 33% of the total stream habitat has been straightened and channelized. In other areas, the channel appears to have been excavated for the purpose of enhancing stream conveyance. Encroachments into the riparian areas and channel modification limit the amount of suitable habitat available to sensitive aquatic species.

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Width-to-Depth Ratio

The width-to-depth ratio in Squaw Creek is estimated to be less than 10. The glide-like streambed common in the creek averages approximately 0.15 to 0.2 meter (0.5 to 0.7 foot) in depth. The channel width averages about 1.5 meters (4.9 feet) across, yielding a width-to-depth ratio of 10 or less.

Streambank Condition

Bank erosion in Squaw Creek is uncommon. Eroding banks are present in small areas of Reach 2 and the upper portion of Reach 3. The erosion in Reach 3 is just below the stormwater outfalls and box culverts located at 35th Street, where large sections of the bank are collapsing into the creek. In other portions of the creek, low stream gradients do not appear to generate enough energy to undermine rooted vegetation and erode bank substrates. Streambank conditions in the Squaw Creek watershed are very stable with little evidence of erosion.

Floodplain Connectivity

With the exception of the channelized portions of Squaw Creek—approximately one-third of the watershed—most of the stream regularly exceeds its banks and inundates the local floodplains. Evidence of ephemeral side channels is apparent in many wetland riparian areas.

Changes in Peak and Base Flow

Some changes in peak and base flow likely have occurred as a result of channelizing and increasing impervious surface. Approximately 33% of the channel has been straightened or confined within artificial banks. These channelized stream segments have a reduced capacity to detain flows during peak runoff events and have little water storage potential. The increase in impervious surface creates quicker, higher spikes in runoff after rainfall events. The magnitude of the changes has not been quantified; however, based on instream indicators such as increased frequency of erosion and channel downcutting, the hydrologic changes associated with development have not been great enough to produce large changes in the channel morphology. The extent to which summertime flows have been altered because of decreased storage capacity has not yet been evaluated.

Disturbance History

Squaw Creek is an urbanized stream. Nearby forest clearing, development, and agriculture have disturbed the entire watershed. Very little mature forest exists in the watershed.

Riparian Reserves

Riparian corridors and setbacks have been established along much of Squaw Creek. These vary in width from a few meters to nearly 100 meters (109.3 yards). In corridor areas—near a technology loop, for example—reestablishment of native riparian vegetation appears to be impaired by invasive species. Overstory trees do not appear to be recolonizing these areas, and

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riparian shading and function have been lost. Many of the undisturbed riparian areas are functioning in a limited capacity. The overstory in these areas provides good canopy closure and shade to the channel. However, invasive species such as Himalayan blackberry and reed canarygrass are colonizing many areas.

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Oak Creek

The Oak Creek watershed is the largest watershed within the study area of this plan. The upper reaches of Oak Creek lie outside the city limits and the UGB. The stream's headwaters are located northwest of Corvallis in McDonald State Forest, on the southern slopes of Cardwell Hills at about 427 meters (1,400 feet) in elevation. Oak Creek follows logging roads southward past Dimple Hill and the OSU Experimental Station. The creek follows Oak Creek Drive, where it is joined by Alder Creek downstream from Skillings Drive. Mulkey Creek joins Oak Creek from the west, downstream from Bald Hill Park. Oak Creek flows under 53rd Street just north of Harrison Boulevard. The lower reaches lie within the Corvallis city limits, beginning where Oak Creek crosses Harrison Boulevard to the south. The stream then flows southeast toward OSU. In this reach it flows through pastures, farm buildings, and research facilities before reaching the main campus. On the south side of the OSU campus, the creek is bounded by the Reser Stadium parking lot to the northeast and mixed residential use to the southwest. As Oak Creek leaves OSU, it flows through a short residential section before flowing under Highway 20/34 and entering the Mary's River.

The Oak Creek watershed contains 8,300 acres. The largest land use is state forest, which covers almost 5,900 acres, representing more than 70% of the watershed. About 12% of the watershed, 1,030 acres, is used for agricultural purposes. Both the forestland and agricultural land are managed by OSU. With the addition of the campus itself, OSU manages almost 90% of the land in the watershed. More than 500 acres are listed as undeveloped.

Under future development, the undeveloped land may be built out as light residential and some of the OSU agricultural land may be developed for university non-agricultural purposes. The amount of impervious surface in the watershed will increase only slightly under these conditions.

<u>Temperature</u>

The City is assessing temperature regimes in the drainage.

<u>Sediment/Turbidity</u>

High, fine sediment loads and turbidity are likely natural features of the Oak Creek drainage. The banks of the creek are composed of alluvial soils that are easily eroded and suspended in the water column. Because of its low gradient (less than 1% slope), the stream may often lack the velocity to transport eroded fine sediment out of the drainage. Instead, it settles out in areas with lower velocities. The naturally occurring high level of turbidity and fine sediment in Oak Creek likely have been augmented with fine sediment loads brought about by human activity. Many portions of the upper watershed have been logged recently, likely contributing fine sediment to the stream. Agricultural fertilizers and manure undoubtedly have leached into the stream, increasing the amount of algae in the water and leading to high turbidity.

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Chemical Nutrient Contamination

Data collected by the City (OSU 2001) indicate that concentrations of *E. coli* bacteria in Oak Creek exceed the Oregon Department of Environmental Quality's (DEQ) standard of 126 organisms per 100 milliliters (3.4 ounces) of water (DEQ 2001). The urban chemicals that may be present in this basin are the same as those potentially present in Dixon Creek (see page 21). Some agricultural chemicals such as atrazine and related compounds also may be found in Oak Creek.

Physical Barriers

The concrete exit skirt of the twin box culverts at the Highway 20 creek crossing creates a barrier falls. The incision downstream has deepened since construction of the culverts and left the exit apron perched approximately 1 meter (3.3 feet). No adequate jumping pools exist immediately below the perched apron. Although the falls created by the culverts appears impassable, juvenile chinook salmon have been observed upstream from the barrier as recently as 1994 (Logan 1994). A second fish passage barrier is created by the pop-up dam near the top of Reach 3. The dam is used to create a pool for irrigation withdrawals and is therefore only erect during the dry season.

Substrate

Gravel is the dominant substrate in the mainstem of Oak Creek; however, silt, sand, bedrock, and native clay layers also are common substrate components. Observed gravel substrates were almost always embedded in sand and silt that clogged interstitial spaces and restricted flows through the substrate. Estimates of embeddedness in mainstem reaches decreased from 50% in the lower two reaches to between 20 and 30% in Reach 3.

Silts and other fine sediments dominated substrates in the tributary streams. These small streams appear to lack a source of coarse substrate and have insufficient energy to transport and distribute such substrates. The high level of fine sediment in these streams is more a function of the surrounding geology and hydrologic state of the streams than any human habitat alterations.

Large Woody Debris (LWD)

The concentration of LWD in the watershed is estimated to be approximately 87 pieces per kilometer (54.0 mile). The NMFS standard for PFC is 80 pieces of LWD per mile; however, NMFS defines LWD as being 60 centimeters (23.6 inches) in diameter and at least 15 meters (49.2 feet) long. In the survey, woody debris was counted as LWD if it was 10 centimeters in diameter and 3 meters long. Because very few pieces of woody debris counted in Oak Creek would meet the NMFS criteria, concentrations of LWD do not meet the NMFS standard for PFC.

Downed trees contribute little habitat in the lower reaches of the creek. While concentrations of LWD are more substantial in reaches 2 and 3, they do not approach the amount of LWD that historically was present in the creek. Large woody debris does not contribute significantly to habitat complexity and only rarely creates deep sheltering pools important for salmonid rearing.

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Pool Frequency

Pool frequency may not be an appropriate indicator for evaluating the aquatic habitat in Oak Creek. Because of its low gradient, the creek contains an abundance of pool habitat. These pools are often extensive (one measured 64 meters [70 yards] in length) and contain long, glide-like tail-outs. The length of many pools limits the frequency with which they occur.

Pool Quality

Pool quality in Oak Creek tends to be low. Most pools are less than 1 meter (3.3 feet) deep and frequently lack objects such as LWD or boulders that provide instream cover and shelter from high stream flows. The most common form of cover in the creek is undercut living root wads. These provide fish with hiding places for predator avoidance but may not be suitable for shelter from fast current during high flow events. With the exception of the one large debris jam in Reach 3, LWD in the creek at the time of the survey did not provide significant sheltering areas that juvenile salmonids would use to avoid high wintertime flows.

Off-Channel Habitat

The deep and narrow incision of the creek offers little opportunity for development of off-channel habitat. Important slack water features such as side channels, oxbows, and large root wads are absent or rare in Oak Creek. With few structures to deflect the current and no floodplain to disperse the energy of the stream, fish have few places to take refuge from the high flows that fill the incised channel. Many likely are washed out of the drainage during high flow events.

Refugia

Historically Oak Creek was a highly braided, sinuous stream likely bordered by floodplain wetlands and gallery woodlands. Euro-American settlement of the area has resulted in stream channelization, riparian forest clearing, and wetland conversion (OSU 2001). As a result of these activities, very little aquatic refugia still exists on Oak Creek. The deeply incised channel precludes formation of off-channel habitat and floodplain wetlands that are usually associated with refugia. The riparian corridor is narrow, often ending at or near the top of the streambank, and is insufficient to buffer any areas of refugia that may exist. Invasive species such as Himalayan blackberry and reed canarygrass are prominent species along many portions of the creek. As a result, very little remnant habitat for sensitive aquatic species exists in the watershed.

Width-to-Depth Ratio

The width-to-depth ratio of Oak Creek was estimated to be less than 10. Channel incision prevents the channel from spreading out into shallow riffles or glides. The high proportion of pool habitat, especially in Reach 2, gives the stream consistently deep residual depths. Because of its low width-to-depth ratio, the creek is less prone to temperature fluctuation. The relatively large volume of water in the channel may buffer the stream against rapid temperature increases during summer heat waves.

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Streambank Condition

The surveyed portion of Reach 2 was the only surveyed area in Oak Creek in which more than 10% of the streambanks were eroding. Approximately 14% of the banks in the surveyed stretch of Reach 2 was eroding, whereas only 9% of the streambank in Reach 1 was eroding. Reach 3 had the lowest proportion of eroding bank, with only 3% of the bank showing signs of active erosion. Bank erosion in the tributary streams was uncommon and was estimated to be well below the 10% threshold established by NMFS as properly functioning.

The relatively low amount of bank erosion in such a highly disturbed watershed may be attributed to two factors. First, the bulk of channel incision probably occurred in the early part of the 20th century as wetlands were drained and channels modified to create agricultural lands and develop the city of Corvallis. The channel may now be approaching a stage of equilibrium. The channel likely has carved away enough width and depth to accommodate its bankfull flows without eroding its banks. Second, the lower streambank in many portions of the creek is composed of clay layers and cemented alluvial materials that are only slightly erodible. These slightly erodible bank substrates likely slow the rate of erosion in many parts of the creek.

Floodplain Connectivity

Floodplain connectivity along Oak Creek has degraded dramatically since the 1940s. Benner (1984) describes the Oak Creek channel near the current location of the OSU Coliseum as being braided as recently as 1936. The land near Oak Creek was described as “low, wet, and especially prone to flooding.” By 1956, the channel was becoming incised and the historical floodplain was becoming isolated from the creek (Benner 1984). As channel incision progressed, the riparian wetland became perched above the streambed. Floodwaters inundated and recharged the riparian areas less frequently, the water table deepened, and the wetlands were converted to agricultural uses. Hyporheic connections between the stream and floodplain were severed as the channel began to erode into non-permeable clay layers and cemented alluvium.

In its current entrenched condition, the creek has little or no connectivity with its historical floodplain. The low terraces present in Reach 3 have created a new, narrow floodplain below the high terraces of the creek bed.

Changes in Peak and Base Flow

Changes in the peak and base flows of Oak Creek undoubtedly have resulted from channelization, deforestation, and wetland conversion. Channelization of Oak Creek has reduced the capacity of the stream to detain and store water during periods of high runoff. Spikes in discharge are generally greater in magnitude and shorter in duration than historically. Loss of riparian wetlands likewise has reduced the watershed’s capacity to store water and likely results in higher peak flows and lower base flows. Deforestation in the Oak Creek drainage also likely resulted in changes to the stream’s hydrologic regime. Removal of vegetation from a watershed or changes in vegetated communities from communities with high rates of transpiration to communities with low rates of transpiration may result in higher magnitude peak flows (Brooks

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et al. 1991). However, deforestation may lead to higher base flows. Because deforested areas tend to have a lower transpiration rate, a greater proportion of the water percolates into the water table. By recharging the water table more efficiently, the deforested areas can create reservoirs of groundwater that will gradually seep out during the dry season (Brooks et al. 1991).

The precise nature of the changes to the hydrograph of Oak Creek is unknown. It is likely that current peak flows are greater than historical magnitudes because of channel incision, wetland conversion, and deforestation. Changes in base flow levels are difficult to evaluate because of the opposite and competing effects of deforestation and wetland conversion.

Disturbance History

Timber harvest and the conversion of land for agricultural and municipal purposes have disturbed much of the Oak Creek watershed. The headwaters of Oak Creek are in McDonald State Forest, which has been extensively harvested. The Oak Creek valley between the experimental forest and the Willamette valley is a mosaic of private properties, with high levels of disturbance. Where the Oak Creek channel meets the Willamette valley, commercial, residential, and agricultural land uses have resulted in riparian degradation and loss of wetlands.

Riparian Reserves

The riparian areas along Oak Creek are highly fragmented, narrow bands of vegetation that often inadequately shade the stream channel. The riparian vegetation along much of the creek is restricted to the area between the edge of the stream and the top of the bank. Although stream shading in these areas is sometimes adequate, gaps in many places in the canopy leave the channel exposed to solar heating. The lack of a riparian buffer in these areas also decreases the potential for LWD recruitment into Oak Creek.

In areas where the riparian vegetation extends beyond the top-of-bank, it is often limited to the 10 or 15 meters (or   feet) beyond the top-of-bank. Stream shading in these areas is generally better than in stream segments with narrower riparian zones, but the lack of a floodplain and riparian wetlands limit riparian functioning. Few large tracts of wide riparian areas exist in the watershed. Large tracts of native riparian forest exist near the covered bridge and bike path crossing in Reach 3, and along the Bald Hills tributary. These areas contain remnants of the gallery forests and riparian wetlands that were once common along the stream.

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Sequoia Creek

The Sequoia Creek headwaters originate near Chip Ross Park. The creek runs generally southeast through residential development then turns eastward near Sycamore Avenue. It crosses beneath Highway 99W and the Willamette and Pacific Railroad trestle before turning to the northwest at its junction with Village Green Creek. After being joined by Village Green Creek, Sequoia Creek turns eastward, where it is known as Stewart Slough. The creek crosses beneath Highway 20 and ultimately discharges into the Willamette River.

The Sequoia Creek watershed contains 1,357 acres. The largest land use is low-density residential, which covers approximately 34% of the watershed; medium- and high-density residential make up another 14%. City streets and ROW take up approximately 14% of the available area. Approximately 12% of the land use is industrial, primarily located downstream from Highway 99W. Open spaces make up about 11% of the watershed. Land use in the remaining areas of the watershed includes a mixture of commercial properties, OSU, and vacant land.

As development proceeds, the vacant land may be converted to low-, medium- and high-density residential use. Other changes may include a decrease in industrial land use and an increase in commercial use. The number of acres of impervious land will increase from 543 acres to 650 acres, thus affecting the quantity and quality of stormwater runoff in the watershed.

Watershed Findings

The condition of the watershed was evaluated using information from a number of sources, including public comments collected at open houses, City staff input on maintenance and operations issues, a technical stream evaluation of selected reaches, and modeling the conveyance system for existing and future build-out scenarios.

The elevation of the channel drops quickly relative to the horizontal distance, thus defining a steep gradient upstream from Walnut Boulevard. The gradient flattens out below that point, creating the potential for flooding in the transitional area between the hills and the flat area near the terminus of the creek. The gradient is very flat downstream from 9th Street, thereby increasing the potential for flooding during large storm events.

Riparian conditions vary along the length of the stream. Unlike those of other Corvallis streams, the riparian areas of Sequoia Creek are more natural toward the downstream end. Industrial land use encroaches on the creek near Jack London Street. A large number of debris dams in the creek downstream from Jack London Street obstruct flows. The recycling facility along the north bank of the creek downstream from Highway 99W is an example of industrial land use encroaching on the stream. Sediment accumulation at the culverts under 9th Street may restrict higher flows.

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Mary's River

The Mary's River watershed portion of this planning effort contains three small drainages that lie south of the Corvallis Country Club. The drainages are outside the city limits but inside the UGB. Flows from the drainages run southward underneath Brooklane Drive before entering the Mary's River floodplain. The 78 acres of the drainages were modeled from the culverts underneath Brooklane Drive to the top of their drainages at the crest of the hill. The existing land use is split between low-density residential and open space, but the area is undergoing significant development. Plans are for low-density residential to cover 69 acres, with the rest designated for open space conservation. Another subdivision, Park Estates, also is being constructed farther east in the Mary's River watershed. Park Estates is south of the Oak Lawn Memorial Park and has its own piped drainage system. This subdivision was not examined in detail or modeled, but is included for the sake of completeness.

Temperature

The Mary's River is listed on the DEQ's 303(d) list for temperature exceeding the 64°F (17.8° C) standard for rearing salmonids. Temperatures exceed the standard on a yearly basis and have been recorded as high as 82.4° F (DEQ 2001).

Chemical/Nutrient Contamination

The Mary's River is listed on the DEQ's 303 (d) list of water-quality limited bodies for bacterial contamination. Fecal coliform levels exceeded state standards in 24% of the samples taken (DEQ 2001). The Mary's River also contains some levels of atrazine compounds according to the USGS (Harrison et al. 1997).

Sediment/Turbidity

The Mary's River is turbid and has a high level of fine sediments. Visibility at moderate to low flows was approximately 0.6 meter (2.0 feet). Fine sediments are the dominant substrate type. The turbidity and high level of fine sediments is a function of the local geology and land usage. The soft, loamy soils that dominate the banks of the river are easily eroded and suspended in the water column. Deforestation of riparian areas and headwater streams also likely contributes to high levels of suspended sediment. Turbidity also may be affected by increases in nutrient levels from agricultural fertilizers. Increased phosphorous and nitrogen levels will lead to increased concentrations of free-floating algae.

Physical Barriers

The surveyed reach of the Mary's River contains no potential barriers to fish passage.

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Substrate

Where the river was shallow enough to assess the substrate, sand and fine sediments or gravel were dominant. However, a layer of non-erodible, cement-like alluvium also is common on the channel bottom.

Large Woody Debris (LWD)

Fifty-four individual pieces of LWD, 16 accumulations, and 10 jams were present in the portion of the Mary’s River within the UGB. Many of these create small back eddies that could provide refuge during high flows.

Pool Frequency

Pool or pool-like run habitat comprises more than 95% of the habitat in the Mary’s River. The scarcity of riffle habitat and abundance of slack water habitat may limit salmonid use of the river. Riffles are important in creating foraging opportunities for salmonids, and the lack of such habitat decreases its suitability as habitat for these species. Therefore, the high amount of pool and slack water habitat in the Mary’s River probably is not a good indicator of habitat quality.

Off-Channel Habitat

Only three small areas of off-channel habitat were observed on the Mary’s River. The incised nature of the channel limits the formation of off-channel habitat.

Refugia

The Mary's River within the UGB contains no significant aquatic refugia or remnant areas of pristine habitat. Water withdrawals, riparian degradation, and alteration of the historic floodplain and hydrograph have led to systemic changes in the aquatic habitat.

Streambank Condition

Approximately 570 meters (624 yards) of eroding streambank was present in the 6,100 meters (6,671 yards) of surveyed reach of the Mary’s River. The large amount of erosion likely is the result of historic human activities, as well as the local geology and the sinuous nature of the river. Most of the erosion is on the outside edge of channel meanders or is associated with LWD accumulation and jams. Bank erosion appears to be just as common in areas with extensive riparian buffers as in those developed for agriculture or residential purposes. A variety of bank stabilization strategies such as planting, concrete retaining walls, and riprap revetment are employed in the lower portion of the reach.

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Floodplain Connectivity

Floodplain connectivity of the Mary's River is low. The channel is incised 4 to 5 meters (13 to 16 feet), making over-bank flows uncommon. Potential riparian wetlands are perched; hyporheic nutrient and water exchanges have been severed or substantially altered.

Change in Peak/Base Flows

Water rights in the Mary's River have been over-allocated. Instream rights exceed flows during the months of September, October, and November. Instream rights plus allocated rights exceed flows from June through November. The over-allocation of water has been implicated as a likely cause of the decline in the Mary's River cutthroat trout population (Ecosystems Northwest 1999).

Disturbance History

The Mary's River watershed is highly disturbed. Private and public timberlands in the upper reaches of the watershed have been heavily logged in the last century. Very few late successional stage old-growth stands exist in the timberlands of this region of the coastal range. Many stands are young second- or third-growth forests. The Willamette valley portion of the watershed also has been heavily altered. Once covered in native wetland and upland prairies and gallery forests, the valley bottom portion of the watershed has been converted to agricultural lands.

Riparian Reserves

Riparian reserves have been significantly depleted along most of the Mary's River within the UGB. Agricultural fields, residential developments, roads, parks, and a golf course are all located adjacent to the river. Riparian vegetation often is restricted to a narrow strip of streambank between the top-of-bank and the wetted channel. Invasive species have colonized much of the riparian area. Himalayan blackberry commonly grows on the streambanks and reed canarygrass is the dominant species along the margins of the channel.

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Willamette River

<u>Habitat Features</u>

The Willamette River forms the eastern edge of Corvallis' UGB. SHAPIRO biologists walked the western shoreline to identify important habitat features and problem areas.

The western shoreline can be divided into three distinct and approximately equal reaches: a side channel reach, a mainstem reach, and a mainstem reach with revetted banks (see map).

Near its southern end, the UGB is bordered by a series of side channels of the Willamette River. These side channels are deeply incised and contain very little off-channel habitat. Narrow, low terraces are present on both banks. The low terraces increase in width near the confluence with the Willamette River. Substrate in the side channels is an even mix of fine sediments and gravel. Riffle habitat is uncommon. Concentrations of LWD are low, probably the result of channel incision and width as well as lack of upstream recruitment. The channels are separated from agricultural fields by narrow strips of riparian vegetation. The widths of these riparian areas average approximately 15 meters (50 feet) and are often limited to the area below the top-of-bank. Riparian vegetation consists of cottonwood (*Populus* sp.), Oregon ash (*Fraxinus latifolia*), and Douglas fir (*Pseudotsuga menziesii*). Reed canarygrass is the dominant species near the water's edge.

Between its confluence with the side channel and its confluence with the Mary’s River, the mainstem Willamette River is only partially incised. In Willamette Park, much of the west bank slopes gently and has been contoured into several overflow channels. These overflow channels create alcoves of off-channel habitat. The substrate of the mainstem appears to be dominated by cobble and gravel. Fine sediment and gravel are the dominant and subdominant substrates in the overflow channels. The riparian overstory is dominated by cottonwood and Oregon ash. Himalayan blackberry is the dominant understory shrub.

Downstream from the confluence with the Mary’s River, the mainstem channel becomes confined between riprap-lined banks. No off-channel habitat or refuge is in this reach. The riparian area is very narrow and is largely composed of willow (*Salix* sp.) and blackberry bushes. The instream habitat is composed of a single continuous run. Highway 20 closely parallels much of this reach and limits the potential for any rehabilitation.

The Willamette River receives all the agricultural and urban chemicals listed for the previous streams. It also receives heated effluent from the City’s wastewater treatment plant. These wastewater discharges are monitored by the City and form part of the baseline.

<u>Temperature</u>

The Willamette River is listed on the DEQ’s 303(d) list for temperature during the summer months. The City conducts temperature monitoring in association with its facilities.

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Sediment/Turbidity

The river is considered to be properly functioning in this category.

Chemical Contamination

See Dixon Creek for a list of urban chemicals that may be in this basin. The river also may have some agricultural chemicals, such as atrazine and related compounds. Nutrient levels are considered to be properly functioning. The Willamette River has a mercury advisory in this area and also is listed for fecal coliform and *E. coli* bacteria.

Physical Barriers

The Willamette River in this area contains no physical barriers to fish movement.

Substrate

The river is considered to be not properly functioning in this category, likely because of the input of fines.

Large Woody Debris (LWD)

Habitat surveys indicate that little LWD is in the system, likely because of changes in the riparian forests and river maintenance issues.

Pool Frequency and Pool Quality

This is considered to be properly functioning in this section of the river, but some areas are at risk. The construction of revetments has changed the way the river responds, but as these generally occur on one side only, they shift the stream activities to the other side.

Off-Channel Habitat

This is considered to be properly functioning in this section of the river.

Refugia

Intact, well-buffered riparian areas exist in very few areas. Residential and commercial developments, city parks, and agricultural fields all encroach on Willamette River riparian areas. This disturbance to riparian habitat has aided the introduction of invasive species such as reed canarygrass and Himalayan blackberry. Encroachments into the riparian areas and channel modification limit the amount of suitable habitat available to sensitive aquatic species.

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Width-to-Depth Ratio

The width-to-depth ratio is greater than 12 in most of the mid- and upper reaches of the mainstem Willamette River. This resembles the historic condition, which likely was heavy braiding on a broad alluvial floodplain.

Streambank Condition

Riprap is present in some areas, making it difficult to classify this indicator as properly functioning. Portions of the stream still have streambanks more similar to the historic condition (see above).

Floodplain Connectivity

This feature is likely to be at risk or not properly functioning. Connectivity with the floodplain has been removed on the west side of the river to control flooding.

Changes in Peak/Base Flow

Some changes in peak and base flows probably have occurred as a result of channelizing and increased impervious surface. These channelized stream segments have a reduced capacity to detain flows during peak runoff events and have little water storage potential. The increase in impervious surface creates quicker, higher spikes in runoff after rainfall events. The hydrologic changes associated with development likely have produced changes in the channel morphology.

Disturbance History

The Willamette River in the study area is an urbanized system. Increased impervious surface, riparian forest clearing, development along the tributaries and the mainstem, and agricultural practices have disturbed the river. Very little mature forest exists in the area.

Riparian Reserves

Some riparian areas still exist, especially near Willamette Park, but riparian systems have been heavily altered.

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JACKSON-FRAZIER-VILLAGE GREEN CREEKS

This watershed consists of the Jackson, Frazier, and Village Green creeks that form a complex network of streams and wetlands to the north of the Corvallis city limits. Jackson and Frazier creeks both originate in McDonald State Forest. The headwaters of Jackson Creek are located near Dimple Peak, while Frazier Creek originates farther north near Lewisburg Saddle. The two creeks flow eastward through the state forest and into low-density residential developments prior to merging at Highway 99. East of Highway 99, their combined flow enters the Jackson-Frazier Wetlands, an important habitat area. The flow leaving the wetlands is split. Part of the flow heads northeast across farmland to connect with the Willamette River at Bowers Slough, downstream from Lower Kiger Island. The remaining flow runs south from the wetlands as Village Green Creek. Village Green Creek turns to the southeast, flows through largely residential neighborhoods, and eventually joins Sequoia Creek to the east of Conser Street.

The Jackson Creek portion of the watershed contains more than 1,500 acres, of which forestland is the largest land use (approximately 700 acres). More than 400 acres is undeveloped. In the future, the forestland will still be present, but the undeveloped land may largely be replaced by low-density residential development. The Frazier Creek drainage area is larger, with more than 2,200 acres in its drainage boundary. Like the Jackson Creek area, the largest land uses are forest (1,000 acres) and undeveloped land (approximately 600 acres). In the future, the undeveloped land may become part of almost 900 acres of new low-density residential. Two-thirds of the 380 acres draining to Village Green Creek are residential. This mix of low-, medium-, and high-density residential will remain the same in the future. The area designated as open space will increase slightly, from 28% at present to 33% in the future.

Input on watershed conditions was obtained by collecting public comments at open houses, working with City staff to identify maintenance and operations problems, conducting a technical stream evaluation of selected reaches, and modeling the conveyance system for existing and build-out scenarios. This information was compiled by stream reach and is summarized in the stream reach description section of this chapter.

Village Green Creek is typical of many urbanized streams. It is highly channelized and in many locations has little or no available shade. Few structures encroach on the streambank, unlike many other Corvallis streams. The open streambanks, such as at Village Green Park, are potential sites for projects to enhance stream and riparian health. For instance, in many areas of this watershed, the floodplain can be reconnected to the stream, thereby enhancing habitat as well as alleviating downstream flooding.

The Jackson-Frazier Wetlands are a key component of this watershed. The wetlands lie just downstream from Highway 99 and receive the combined flows of Jackson and Frazier reeks. The natural drainage through the wetlands has been modified, affecting the flows through the system. A berm along the southern perimeter of the wetlands is one of the more obvious signs of modification. At present, flows leave the wetlands via a drainage ditch to the northeast and by Village Green Creek to the south. A number of studies, most coordinated through OSU, have been conducted on the wetlands' vegetation and wildlife. The wetlands are part of Benton County's park system, and contain a raised boardwalk used for an interpretive trail. However,

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only limited information exists on the wetland hydraulics. Additional information and analyses are needed to better determine how the wetlands react to large storm flows.

Above the wetlands, Jackson and Frazier creeks flow through mainly agricultural lands with low-density residential development concentrated along the streams. Many stream reaches are in relatively good condition with a fair amount of canopy cover and few erosion problems. Other reaches have more development, resulting in constrained channels and bank erosion. One example of this is the campus of Crescent Valley High School, where six different bridges and box culverts cross the stream.

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CORVALLIS ESA RIPARIAN MAPPING SUMMARY

All comments apply only to the area within the 400-foot- (122-meter-) wide riparian corridor.

Dixon Creek

- The mainstem (south of Walnut Avenue) is almost completely residential.
- The majority of the mainstem, although residential, includes a narrow strip of deciduous forest canopy that shades the channel.
- Street crossings that dissect the riparian zone are common on the mainstem.
- Tributaries (north of Walnut Avenue) generally are either in strips of deciduous forest bordered by unmaintained herbaceous vegetation or in continuous deciduous forest.
- Street crossings north of Walnut Avenue are uncommon or nonexistent.
- Some first-order tributaries are in herbaceous vegetation.

Oak Creek

- Most of the stream is bordered by a narrow strip of forest canopy.
- The lower 0.8 kilometer (0.5 mile) (downstream from 35th Street) includes commercial/industrial and residential development; road crossings are common.
- Upstream from 35th Street, the forested area varies from very narrow to the full width of the riparian area, averaging one-third to one-half of the corridor width.
- Agricultural lands make up most of the remainder of the corridor above 35th Street.
- Above 35th Street, road crossings occur every 0.4 to 0.8 kilometers (0.25 to 0.5 mile).

Mary's River

- The riparian buffer along the Mary's River consists mostly of deciduous forest that extends the full 61 meter (200 feet) on each side of the stream.
- The forest strip is contiguous on both sides of the stream, for the full length of the stream within the UGB.
- A small amount of agricultural land is located on the outer edges of the corridor just downstream from the point where the Mary's River flows into the UGB.

Squaw Creek

- Six major or complex road crossings fragment the system.
- Scattered but generally small pockets of commercial/industrial and residential development impinge on the corridor in several places.
- A forested strip is adjacent to nearly all of the stream, including the mainstem, north fork, and south fork; it averages about one-third the total width of the corridor.
- South of Philomath Avenue, the remainder includes residential, commercial/industrial, and infrastructure developments
- North of Philomath Avenue, the remainder consists mostly of agricultural lands.

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SUMMARY

The streams in the Corvallis area, with the exception of the Willamette River, contain no listed species, nor is there any historical record of spawning or rearing in any of them. It is likely, given their size, hydrology, and geomorphology, that they have never been chinook streams. Despite this, the streams play a role in the baseline water quality of the Willamette River and have been known to serve as high-water refuge habitat. They still could do so.

The Willamette River is different, however, as both immigrating adults and emigrating juveniles use the area in front of Corvallis as a passageway. Adults move upstream from April through June and juveniles move downstream from February through May. Conditions in the mainstem Willamette River in this area are not suitable for spawning or rearing and so are not affected by City activities. Some additional movement occurs in October and November. It may be that the off-channel habitat on the east side of the river is used as a resting area. This makes activities in the Willamette River more critical in terms of take of listed species.

It is clear from the available data that the baselines of all the streams, including the Willamette River, are degraded considerably from what they may have been prior to human settlement. They are urban streams and show all of the attendant characteristics. While this plays a very small role in the establishment of the baseline condition, the distinction becomes more important when a trajectory for recovery is considered.

ADMINISTRATIVE REVIEW

The objectives of this element of the analysis were: (1) to determine, through review of City ordinances, administrative rules, and adopted policies (regulations); those activities that could cause a beneficial or negative impact on Upper Willamette spring chinook or its habitat; (2) to identify the regulatory gaps, including those activities currently unregulated by the City or any other regulatory entity, which could have an impact on Upper Willamette spring chinook or its habitat; and (3) to provide a measure of the relative magnitude of each impact.

The analysis phase consisted of assessing the City's regulations for potential impact upon listed species. Each component of the regulations was evaluated for its potential impact on critical habitat, listed species, and properly functioning habitat conditions, as NMFS has identified these major areas as being critical for its definition of take under Section 9 of the ESA.

These activities were assessed as to their perceived impact (beneficial or detrimental) on PFC within an appropriate geographic scale designation. The pathway for the impact was listed as well. This analysis includes an assessment of regulatory gaps where the City could influence the protection and recovery of listed fish and habitat.

The detailed information produced in this analysis will be incorporated into the next phase and used for determining policy changes and restoration efforts. Codes were examined using the following approach. The activity was first assessed as to whether or not an effect exists. Next,

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determination was made as to whether or not the effect is direct. The next level of assessment determined the duration, intensity, and magnitude of the effect.

The critical element was to take the information gathered from the regulations analysis and create a simple, effective tool to evaluate the potential for 4(d) compliance/noncompliance. A matrix was developed listing each regulation, its scope/spatial scale, duration, and intensity, and the potential impact this regulation would have on the habitat-forming parameters listed above.

The matrix was organized by habitat element and general regulatory category, with specific regulatory actions listed underneath. The possible impact was listed, with an indication as to whether the impact was a direct result of the action or an indirect result of the action (if intermediate steps occurred, as explained in earlier tasks). The potential intensity of the impact was assessed at this time, as well as the area of impact.

In assessing the magnitude of City regulatory impacts on listed salmonids and their habitat, it is important to be as quantitative as possible. Therefore, the City is using a system similar to that used in numerous environmental impact assessment studies to make this magnitude assessment. The approach described below divides the impacts into the factors of interest and uses clearly defined and repeatable categories to determine their magnitude.

Each activity was scored, using a standard three-point scale, as to the importance of its perceived impact on each element of habitat functioning. Scoring was done using an assessment of the duration, spatial scale, and intensity of the action, as stated in the general data analysis and evaluation section above.

Spatial scale of the impact was assessed using a geographic scale (i.e., watershed-level or stream reach-level). Small-scale events can be multiplied up through the scales to reflect a watershed-level approach. This is important as their impact may vary on a considerably smaller scale, despite the citywide nature of the regulatory activities. Intensity was a value judgment as to the nature or concentration of the activity. Multiplying all three elements together provided a score for each activity, allowing the process to be replicated by individuals not involved in the initial assessments.

Overview of City Development Activities

The following discussions are from the Corvallis Stormwater Master Plan and refer to the development activities projected for the City's watersheds. This sets the framework for discussions of projected development and the impacts resulting from it, as defined by the regulatory analysis matrices. The discussions cover current land use and projected build-out, as well as changes in impervious surface in the various stormwater subbasins.

Dixon Creek

If the watershed is developed to full build-out according to the City's Comprehensive Plan (1998), the current vacant land may be largely converted into low- and high-density residential use. Other changes may include a decrease in medium-density residential land use and an

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increase in commercial use. Overall, the number of impervious acres is estimated to increase by 13%, from 897 acres to 1,017 acres.

Garfield Watershed

The Garfield watershed lies between the Dixon Creek watershed to the south and the Sequoia Creek watershed to the north. The topography of the watershed is flat with slopes of less than 3%. The Garfield watershed soils are poorly drained silts, reflecting the area's origin as alluvial terraces formed by the Willamette River. The upper reaches of the watershed are almost completely developed and their high degree of imperviousness contributes much of the flows through the relatively undeveloped reaches downstream from Highway 99. Most of the watershed also experiences a high groundwater table that reduces the volume and rates of stormwater infiltration.

The Garfield watershed contains less than 350 acres, making it one of the smallest watersheds in the Corvallis area. Currently, 70% of the watershed is zoned as industrial. The City's comprehensive zoning plan indicates that in the future the industrial-zoned area may drop to 61%; however, the amount of impervious surfaces will remain constant because of an increase in commercial zoning.

Sequoia Creek

The Sequoia Creek watershed contains 1,357 acres. The largest land use at present is low-density residential, which covers approximately 34% of the watershed. Medium- and high-density residential account for another 14%. City streets and ROW make up approximately 14% of the available area. Approximately 12% of the land use is industrial, primarily located downstream from Highway 99W. Open spaces make up approximately 11% of the watershed. Land use in the remaining areas includes a mixture of commercial properties, OSU, and vacant land.

As future development occurs, the vacant land may be converted into low-, medium- and high-density residential areas. Other changes may include a decrease in industrial land use and an increase in commercial use. The number of acres of impervious land will increase from 543 acres to 650 acres, thus affecting the quantity and quality of stormwater runoff in the watershed.

Jackson-Frazier

The Jackson Creek portion of the watershed contains more than 1,500 acres, of which forestland is the largest land use (approximately 700 acres). More than 400 acres is undeveloped. In the future, the forestland will still be present, but the undeveloped land may largely be replaced by low-density residential development. The Frazier Creek drainage area is larger, with more than 2,200 acres in its drainage boundary. Like the Jackson Creek area, the largest land uses are forest (1,000 acres) and undeveloped land (approximately 600 acres). In the future, the undeveloped land may become part of almost 900 acres of new low-density residential development. Two-thirds of the 380 acres draining to Village Green Creek are residential. This mix of low-, medium-, and high-density residential will remain the same in the future.

Squaw Creek

The largest land uses in the Squaw Creek watershed are low-density residential (766 acres) and vacant land (609 acres). Industrial and commercial land use is mostly limited to the Sunset Research Park and along Philomath Boulevard (Hwy 20/34). In the future, if the watershed is developed according to the City's comprehensive plan, all of the vacant land may be developed with most of it converted to residential land use. In addition, medium- and high-density dwellings will make up an increasingly larger portion of the residential land use. As a result of these changes, the amount of impervious land may increase from 762 to 968 acres, an increase of 27%.

Oak Creek

The Oak Creek watershed contains 8,300 acres. The largest land use is state forest, which covers almost 5,900 acres, representing more than 70% of the watershed. Approximately 12% of the watershed (1,030 acres) is used for agricultural purposes. Both the forestland and agricultural land are managed by OSU. With the addition of the campus itself, OSU manages almost 90% of the land in the watershed. More than 500 acres are listed as undeveloped.

Under future development, the undeveloped land may be built-out as light residential and some of the OSU agricultural land may be developed for non-agricultural university purposes. The quantity of impervious surface in the watershed will increase only slightly under these conditions.

Mary's River

The existing land use is split between low-density residential and open space, but the area is undergoing significant development. In the future, low-density residential will cover 69 acres, with the remainder preserved as open space conservation. Another subdivision, Park Estates, also is being constructed farther east in the Mary's River watershed. Park Estates is located south of Oak Lawn Memorial Park.

ANALYSIS OF THE CITY'S REGULATORY ENVIRONMENT AND ITS INFLUENCE ON THE HABITAT BASELINE

The greatest impacts on the habitat baseline occur, obviously enough, in the land use arena. All pathways are implicated, both directly and indirectly. Any development in the area increases the amount of impervious surface, as buildings, parking lots, driveways, streets and roads, etc. Despite this, tradeoffs do occur. The intensity of the impact depends upon the footprint of the development, the location of the development, and the level of treatment, if any, of the associated stormwater runoff. For instance, low-density residential housing has a smaller impervious footprint, in relation to lot size, than do medium- and high-density residential development. Mixed-use commercial development has a potential for a smaller footprint, because of the mixture of commercial and residential, than would areas zoned strictly commercial. General industrial areas require more landscaping and, therefore, a potentially

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smaller amount of impervious surface, than do intensive industrial areas. Areas zoned as open space preserve the amount of pervious surface, and, therefore, are positive. Despite the relatively positive nature of the differing land use types, all but open spaces tend potentially to degrade the baseline. Impervious surface in the stream corridor has a direct and immediate impact on the stream, although if it enters as sheet flow (usually not the case) it may have less impact than water entering by a storm sewer outfall.

Development also has an impact on the riparian buffer. Road crossings and structural encroachments break continuity and species composition is changed, sometimes quite radically. Replacing an oak gallery forest with maintained lawns decreases a great many of the functions of a riparian system, especially those associated with water-quality temperature and filtering. Even a lawn, if compacted sufficiently, can act as an effective impervious surface, and the length of the grass may be too short to be effective as a filter strip or as shade. Again, the various permutations seen above occur: low-density residential housing requires more porous surface, and on up. Any reductions in the impervious footprint translate to more potential gains in the buffer. However, any construction directly on the streambank or in the riparian buffer degrades the function.

Instream habitat also can be affected. The streams are separated from their floodplains, as it is not desired that they cause property damage by flooding, and they become stormwater conduits designed to move water rapidly through the area to the Willamette River. Streams also are constrained by infrastructure development (streets and culverts). These act as barriers: another pathway to habitat impacts.

Daily activities associated with human occupation contribute to the contaminant pathway. Fertilizers, pesticides, and herbicides are commonly used (see Dixon Creek for a list of chemicals found in the stream and their uses). Liquid and solid petroleum products, heavy metals, and bacteria enter the stream systems and affect the baseline as well.

It is important to discern differences in intensity of land use for residential, industrial, and commercial areas. For instance, low-density residential housing may have a greater impact on fish habitat because of yard maintenance issues. Higher residential density may yield more impervious surface run-off. Industrial land use could be heavy or light and, depending on the activity, could have different impacts. The same is true for commercial land use.

Zoning, as it designates allowed land use, determines the extent of impact on the baseline. While it does not necessarily mean that all land in a particular zone is of the type zoned, it does suggest what may occur in the future. Activities planned in the riparian corridor will have a continued detrimental effect on habitat and further degrade the baseline. Activities outside the riparian corridor may not necessarily have this effect, but the potential is there if any of the pathways are operating. As is apparent in the analysis (see Appendix), these pathways are found in most of the development-based activities.

The development code determines what development, zoning, etc. is allowed. Little of the present code addresses habitat impact pathways, although some elements do preserve riparian corridors and open spaces. Other positive elements are those that limit certain of the pathways, such as impervious surface. However, these do not stop the effects of the activity; they only limit the increase. This still causes an increase in the impacts to the habitat and further degrades the baseline.

ANALYSIS OF PARKS IMPACTS AND PATHWAYS

An analysis of parks planning, construction, and maintenance indicates two major pathways for impacts on fish habitat: impervious surface and contaminants. Parks affect habitat through their design and maintenance. Design elements include trails, parking lots, park structures, and playing fields. All of these modify the existing conditions to varying degrees. Since parks have no stormwater facilities, such that most impervious surface becomes effective impervious surface.

Maintenance contributes to the conversion of total impervious surface to effective impervious surface through mowing. While it is likely that some sod areas have some infiltration of stormwater, asphalt and heavily compacted dirt, gravel, and grassy surfaces function to increase sheet flow into the streams. Use of the park itself becomes an issue.

Contaminants take the form of pesticides, herbicides, and fertilizers. Nutrients contribute negatively to a system through runoff into the streams and the resultant potential for eutrophication. Pesticides and herbicides generally are either toxic or are considered to have sublethal effects. Herbicides are applied using backpack sprayers. The City uses Roundup™ and Surflan™on its developed landscape areas and on invasive plants (e.g., blackberries) along stream corridors. The City also has adopted an Integrated Pest Management Program.

The effects on fish habitat from the addition of new parks (parks planning) utilize the same two pathways. New construction also may commit a direct take on critical habitat through placement in the riparian zones of the streams or by usurping other hydrologic features (e.g., wetlands).

However, positive (or neutral) impacts to the baseline may be incorporated in design. Such elements as stormwater treatment swales and water quality strips along riparian zones would serve to maintain PFC, if not actually enhance it. It also may be possible to incorporate restoration actions into new park design, making them truly a positive contribution to obtaining PFC.

ENVIRONMENTAL SERVICES ANALYSIS

The City requires a process to determine which of its operations and maintenance procedures are in compliance with the ESA sections on take of listed species. The recent final 4(d) Rules dealt with limits applied to activities in municipal, residential, commercial, and industrial programs, ordinances, planning efforts, and regulations. The chief concern at this time for the City is with City programs and the impact these programs have on listed species.

The format for this analysis is the same as that for the regulatory programs. Activities were broken down and their elements analyzed as to the nature of their impact on the habitat baseline and the pathways for these impacts. The detailed analysis may be found in Appendix G.

City Infrastructure Programs

City infrastructure activities have a tremendous impact on the habitat baseline. These include stormwater and wastewater systems, potable water systems, street cleaning, and transportation elements. All pathways are implicated in these effects.

Stormwater Systems

The stormwater conveyance system is perhaps the most obvious in terms of its influence and likely the most far-reaching since it serves as the conveyance for a number of the other activities as well. Stormwater issues include: (1) the operation and maintenance of existing stormwater facilities, primarily related to hydrology and water-quality effects, structural effects, and direct habitat effects; (2) construction or retrofitting of stormwater facilities, including facility siting, proximity to water bodies, erosion and stormwater runoff control, maintenance, and habitat disturbance; and (3) control of stormwater sources. These encompass impervious surface area, illicit discharges, pollutants, erosion and runoff from development, standards and regulations, and public outreach and education. Specific stormwater problems include outfalls dumping directly into streams tributary to the Willamette River, changes in tributary stream flows, diversion and piping of streams, and discharge of pollutants into the tributaries. Maintenance activities within the streams and on the streambanks also cause changes in the function of the streams.

Chief among these is the impact upon the streams by changing the hydrograph. This creates problems with instream fish habitat, as well as altering flows and erosion/deposition patterns. In Corvallis' streams, the most-negative impact is the increased sedimentation rate brought about by increased velocities or decreased infiltration as the result of its being a closed system. Another pathway impact is temperature change. Water is warmed by the sun as it sits in detention facilities and pools that form when flows are low in the non-rainy season.

Other negative effects of the stormwater system include culverts which are effective barriers to fish movement (see stream assessment for their locations) and contaminants. Most contaminants in the system are from the use of fertilizers, herbicides, and pesticides to control and maintain vegetation along ditches and streams. Other contaminants and sediments are introduced through the flushing process. Ditch mowing also contributes to runoff and the introduction of contaminants. The removal of LWD from the stream channel and subsequent operation of the streams as stormwater conduits have a negative impact on instream fish habitat.

Wastewater Impacts

Wastewater habitat impact pathways, like stormwater impacts, include the introduction of contaminants and alteration of temperature. There are a number of scenarios involving spills and discharges that would introduce raw pollutants or treatment chemicals directly into the system (spills, overflows, leaking pipes, and pumping system failures, among others). Habitat impacts in these cases are likely to be negligible, but these types of discharges are likely to have both directly toxic and sublethal effects on the fish themselves. Alteration of temperature also may have lethal or sublethal effects on listed species. The City operates its wastewater plant under a National Pollutant Discharge Elimination System permit and is required to monitor temperature and water quality impacts of the facility. Mixing zone impacts to temperatures are governed by the permit and at high water are not critical. Low-flow conditions may cause short-term spikes in river microhabitat temperatures. The potential exists for effects on adult fish, although the possibility is small given the relatively small area of impact and the capability for adult fish to move out of the zone of increased temperature. Juvenile fish would be more greatly influenced by temperature, as their movement capabilities are less; however, there appear to be no rearing juveniles in the Corvallis area. Again, young fish would be influenced by temperature during downstream movements and likely would exit the area before any negative impacts would occur.

New construction, such as planned pipelines along stream systems, would have construction-related impacts (increased sedimentation and erosion), as well as more permanent impacts resulting from the removal of riparian vegetation (the buffer pathway) such as increased temperatures resulting from the loss of shading.

Drinking Water Systems

The potable water system effects include those resulting from direct diversion, such as water intakes, screens, impacts on water quality, and instream flow. The City commits no take through its diversion of water since no life history stages of listed species inhabit Rock Creek, the upstream tributary of the Mary's River affected by the City drinking water system.

For the same reason, instream flow alterations are not a take of listed species. As the City does not use an instream reservoir to supply water, water quality becomes an issue only through back-flushing of the system. The chemicals used in this process, and the potential for discharge into streams tributary to the Willamette River creates a pathway for impacts on listed species. Flushing also may contribute to increased flows in the system, potentially affecting critical habitat. Generally, if the amount diverted is less than 10% of the total flow, it is unlikely that significant hydrological impacts will occur. The distance between the diversion site and the Willamette River, also mitigates against any potential take. Water quality issues arise with the proximity of sites of discharge of flushed water to the above-mentioned tributaries of the Willamette River. It is likely that any water used to flush the system enters the stormwater system and becomes an element to be considered.

Transportation Effects

Impacts from transportation activities result from two major areas: new construction and maintenance. New construction impacts result from construction activities, the road itself, increased traffic, and increased maintenance. Road construction in the stream corridors has a negative impact on the riparian buffer, both in size and continuity, through removal of vegetation, although appropriate mitigation may maintain the species composition or even improve it by eliminating invasive species and replacing them with native forms. The roads

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themselves increase the amount of impervious surface, with the resultant impacts on instream habitat and bank erosion. Construction in the stream corridor also may have a negative impact on wetland areas and instream habitat, directly, rather than through runoff.

Construction outside the stream corridor can still have negative impacts through the impervious surface and contaminant pathways. An increase in runoff into the stormwater conveyance system will have negative impacts on the instream habitat through alteration of the stream's hydrograph, and by the introduction of contaminants from the roadway surface. Increases in the amount of road surface means increases in traffic, leading to more contaminants on the road surface.

Similar impacts to the habitat baseline result from the existing transportation system. Contaminants enter the stormwater system from existing roadways. Maintenance associated with de-icing roads introduces contaminants either directly into the system or into the stormwater system, with the same eventual destination. Similarly, the use of any pesticides, herbicides, and fertilizers, either along the watercourses or in areas where the effluent is conveyed by the stormwater system, have a negative impact on both fish in the systems and critical habitat through effects on the food supply. Roadside mowing decreases the ability of the vegetation to slow overland flow and allow the stormwater to percolate. Bridge washing uses detergents that may have some toxic or sublethal effect on fish or their food organisms.

Road repair uses petroleum-based compounds, that could be transported into the stormwater system, and then to the stream itself, creating a toxic situation. Bridge repairs and painting may introduce substances of unknown toxicity into the systems directly. Culvert cleaning and repair are likely to introduce sediments into the stormwater or stream systems, causing an increase in the total suspended solids. The impacts of this are likely to be sublethal in nature, influencing feeding and navigation capabilities.

SUMMARY

It is clear from this analysis that the majority of City activities, through any and all of the pathways, have a negative impact on the habitat conditions in the streams of the project area. The greatest impact is that of impervious surface, followed by riparian buffer changes and channelization. Impervious surface results not from just the construction of buildings, streets and roads, and parking areas, but also from such seemingly benign activities as trails and parks. The increased runoff is especially important in the upper reaches of the Corvallis streams (especially Dixon, Oak, and Squaw Creeks). While it is also critical on Sequoia Creek, this stream is not crucial to critical habitat for listed species, as the result of the filtering capacity and passage barrier aspects of the Jackson-Frazer wetland complex. While the lower reaches of the other streams are likely completely incised, or nearly so, the upper reaches still retain a great deal of function and hydrologic connectivity. This is likely to change with increased development and the increased amounts of impervious surface that follow.

Riparian functions also are critical, as shade sources to decrease temperatures, as filters for removing contaminants and to help prevent instream and bank erosion. Again, in the lower

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reaches of the streams riparian areas have been severely diminished through development activities.

Channelization results from the increased development in the floodplain of the stream. The need for streams to become stormwater conduits serves to further contribute to incision, and diminishes and eventually removes altogether the floodplain connectivity of the system.

The result of all this activity, along with the basic human activities associated with living, be they urban, suburban or rural, leads to diminished water quality in these streams. Eventually, this makes its way to the Willamette River, where it can become a take.

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